ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 TELEPHONE: TEMPLE BAR 1861

No. 4601 LONDON, FRIDAY, APRIL 2, 1954 PART 2

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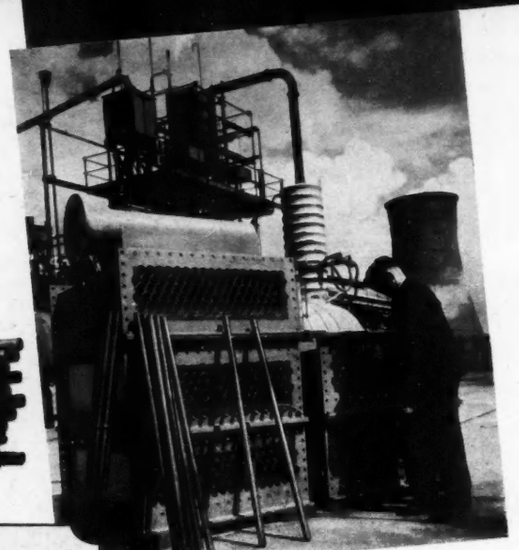

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ENGINEERING

An Illustrated Weekly Journal

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Published every Friday by Engineering Limited
35 & 36 *Bedford Street, Strand, London, W.C.2*
TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

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Subscription Rates for 12 *months, inland and abroad* £5 10*s.*, *Canada* £5 5*s. Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* [2*s.* 3*d.*]

A LEAD FROM THE NORTH

CONSIDER the hopes and doubts of two typical men in the engineering industry: on one hand the head of a firm who suspects he could make a more profitable use of scientific and technical development, if he but knew how to set about it; and on the other, the young graduate or apprenticed engineer who is uncertain as to what kind of firm or organisation he should join for the first, crucial years of his career. Both will derive considerable guidance from a survey of the relations between science and industry which has been carried out by the Manchester Joint Research Council. The report of this survey* gives ample evidence of the opportunities awaiting the young engineer who plans his future with forethought, and it provides management with a scale by which to assess their use of science and technology.

The survey covered 225 firms in the Manchester region, of which 118 (52 per cent.) employed at least one scientist/technologist (a term which refers, broadly, to men with a university degree or with a professional qualification such as membership of one of the major engineering institutions). The total labour force of these firms was 147,000, and their total number of scientists/technologists was 1,297, consisting of approximately equal numbers of graduates and "diploma-holders." The investigators thought that of the firms in which a scientifically trained staff was necessary, 42 per cent. were understaffed and, of these, one-third, mostly small firms, showed no awareness of the fact. One-third of industry, the report states, does not require much from science; another third requires mainly competent application of established principles; and only the final third really needs the aid and stimulus which science alone can give. In the last third the scientifically qualified staff was satisfactory in five-sixths of the firms. In the middle section it was adequate only in two-fifths.

Though it is clear from the report that those firms which have technical men on their boards or in senior positions are usually the most progressive, it is also apparent that firms without such men at the top can make good use of scientists or technologists. It is certainly not necessary to be "a scientist in the formal sense of the word to show resource in utilising scientific knowledge and to make recommendations which are scientifically fairly simple but which yet make possible some quite striking improvement or economy." Especially is this true in relation to plant and process efficiency.

The old complaint that a university graduate may be incapable of appreciating the practical realities of the workshops, or may not fit in with the existing organisation of a firm, is no longer valid. In the few cases where the investigators encountered a complaint of this kind it was usually found that the graduate was a raw recruit, and that failure on his part to fit in was largely due to lack of guidance. The lesson seems to be that a graduate should first join an organisation which already employs men of similar qualifications; later on he may be able to advance himself and his employers in a firm which has decided to take on a scientist or technologist. In either case, the report suggests, his chance of making a significant contribution to engineering will depend on the attitude of top management. If the leaders of the firm are "science-minded," though not necessarily scientifically educated, he will be able to serve them.

The extent of the help that industry and the universities derive from each other is considerable. Even among those firms with no graduate on their staff, 20 per cent. sought help from a university on scientific and technological problems and 8 per cent. on recruitment. Forty per cent. of all the firms had active contacts with a university or technological college. The Manchester area may, of course, be exceptional in this respect since the University and the College of Technology maintain close connections with industry. The connections are based largely on informal personal friendships. It is not necessary for a firm to have a highly qualified staff or extensive laboratories before it can enlist the services of a university.

For the information of the young graduate, the report points out that there is plenty of opportunity for him, provided he realises that his university training is only the first rung of the ladder and does not expect it to qualify him automatically for high executive office. "Personality as a dominant factor in industry" is the heading of one section of the report. "It is the outlook of the chief executives which is the governing factor in determining how widely, and wisely, the resources of science will be employed to stimulate progress and efficiency." Certainly this report will help to stimulate progress and efficiency. It fails, knowingly, to present the whole picture; its statistical evidence is sometimes open to question; and it appears to have suffered somewhat from the fact that none of the three investigators remained to complete the work. But, for all that, it is provocative, enlightening and well worth reading.

* *Industry and Science.* Manchester University Press, 316 Oxford-road, Manchester. (12*s.* 6*d.*)

Weekly Survey

ELECTRIC POWER AND ALUMINIUM

A recent report of the United Nations Organisation estimates that about 3·5 million tons of aluminium will be required in 1955 and that the figure may rise to 4·5 million tons by 1960. The manufacture of aluminium is essentially an electrical process, during which from 8 to 9·5 kilowatt-hours are consumed to produce 1 lb. of the metal. The growing demand for it is therefore accompanied by a correlated consumption of electricity.

These circumstances have encouraged the construction of the Nechako-Kemano-Kitimat hydro-electric development and its associated aluminium reduction plant in British Columbia. The scheme is to cost some £210 million, a sum which is not surprising when the remoteness of the site chosen for the civil engineering work is considered and when, as will be gathered from the account which we give on page 430 of this issue, the generating plant will have a rated output of practically 2¼ million h.p.

To obtain this power the main civil-engineering works include the construction of a rock-fill dam 1,550 ft. long and 317 ft. high, which will impound the run-off of a watershed of some 5,765 square miles at an altitude of 2,800 ft. above sea level and reverse the flow of at least one river. The storage reservoir thus formed will have a capacity of 873,000 million cub. ft. and an average total run-off of 6,920 cub. ft. per second. At a distance of no less than 140 miles west of this dam the water will be taken through two 25-ft. diameter power tunnels, a distance of 10 miles under the Coast Range of mountains, to a power house at Kemano, where it will be utilised under a net head of about 2,500 ft. in the sixteen 140,000-h.p. turbines which will eventually be installed. This power station is in a chamber excavated from the solid rock and is located about 1,400 ft. from the face of the mountain. It is the largest high-head power station in the world, and is only exceeded in capacity by the 3,000,000-h.p. Grand Coulee Scheme.

The generator voltage of 13·8 kV is stepped up to 300 kV for transmission over the 48 miles from Kemano to the aluminium factory at Kitimat on the sea-shore 450 miles from Vancouver. The country traversed first rises to an altitude of 5,300 ft. for a distance of some 10½ miles, after which it falls, to rise again to between 2,000 and 3,000 ft. for a distance of about three miles before finally reaching Kitimat. The route is extremely rough and difficult of access, besides being exposed to heavy icing conditions. It is hoped that the Duke of Edinburgh will formally inaugurate the scheme next July.

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CREDIT FOR ENGINEERING EXPORTS

A number of medium-sized engineering companies have recently received a circular asking them if they would be interested in subscribing to the capital of a new company which it is hoped to establish for providing long-term credit to overseas customers. The scheme is as yet no more than embryonic but its sponsors have been encouraged by the fact that already they have had a more favourable response to their approach then occurred two years ago when the first tentative steps were taken to set up such an organisation. It is certainly true that customers abroad are seeking increasingly favourable credit terms and it is equally true that many British concerns are averse from calling upon their overdraft facilities with their banks to finance buyers' credit, which it is after all the concern of the customer to provide.

The Manufacturers' Export Finance Company, Limited, which would be the company's name on incorporation, would not assume any risk as to the credit-worthiness of the buyer. That would be the province, as at present, of, say, the Export Credits Guarantee Department, and the new company would operate only when an E.C.G.D. guarantee (pre-shipment and shipment) had been obtained and would pay cash on the documents only up to the amount of that guarantee. The cost of the credit would probably be about 6½ per cent. plus the premium of the E.C.G.D. It is envisaged that the new company would have a capital of £250,000 in £1 ordinary shares, of which 4*s*. would be called. A merchant banking house is prepared to put up 20 per cent. of the capital if exporting companies will provide the rest. The uncalled balance of capital would be used as marginal security in negotiating overseas buyers' bills with the joint-stock banks, one of which is prepared to provide £2 million for the purpose over the first few months. The new company would put itself in funds by selling drafts to the joint-stock banks at fixed prices. Its services, which would be available to all exporters of capital goods and not just to its shareholders, would cover all the administrative work connected with obtaining credit and export guarantees. If the company meets with an encouraging response so far as turnover is concerned, its resources will surely have to be expanded considerably.

The idea of facilities which avoid the necessity for the manufacturer to borrow short and lend long in order to carry on his export business is likely to have an increasing appeal as time goes on. Here could be part of the answer, for example, to the problem of challenging the long-term credit facilities offered by German industrialists. Sufficient progress has been made with the idea for it to become a reality if British companies are prepared to back it, and in this respect it follows from the nature of the services which this new company offers that the engineering industry will have to take the lead. At least one well-known engineering firm has already taken an active part in arousing interest in the project. If a substantial amount of support is mobilised, it would probably be of advantage to publicise more details of the auspices under which the new company is to be formed and the names of those engineering firms and others who are prepared to subscribe the capital. Further particulars of the proposals can be obtained from Mr. James Goodwin, 42-45, New Broad-street, London, E.C.2.

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TESTING HIGH-VOLTAGE SWITCHGEAR

The increasing erection of widely-extended electricity supply transmission systems operating at very high voltages and carrying amounts of power which would have been inconceivable a short time ago is providing switchgear designers and manufacturers with some difficult problems. As is well known, one of the chief, though not the only, function of this equipment is to act as a safety valve; or, in other words, to open the circuit should a fault or other abnormality occur. It may not often be called upon to perform this duty, but it must be relied upon to do so should occasion arise. A natural corollary of this requirement is that the gear should be tested under short-circuit conditions, a fact which has been recognised in the establishment of special stations for this purpose.

One of the first, if not the first, of these stations was that commissioned in 1929 at their Hebburn works by A. Reyrolle and Company, Limited, thus enabling exhaustive tests to be made on the performance of the switchgear of that time. It was extended in 1934 to bring its equivalent three-phase output, obtained single-phase, up to 1,100 MVA at voltages up to 132 kV. Since then, however, the demand for switchgear with higher rupturing capacities has increased so rapidly that the test facilities have been outstripped.

This difficulty has now, it is to be hoped, been overcome by the erection of what is virtually a new station, although it operates in close conjunction with the old plant. This station, which was formally opened by Lord Citrine on Tuesday, March 23, and a description of which appears on page 442 of this issue, will enable full-scale three-phase, single-phase or unit tests to be made on any switchgear that is likely to be required in the near future.

Although in earlier days short-circuit outputs equal to the rupturing capacity of the circuit-breaker under test were employed, it was recognised that to do this with a large modern circuit-breaker designed for use at 275 kV and with a rupturing capacity of, say, 10,000 MVA, would be most uneconomical. The technique of single-phase unit testing was therefore developed and has been utilised in designing the new plant. By making use of special generator and transformer connections, by providing over-excitation and by applying the short-circuit at any selected point of the voltage wave to control the degree of asymmetry and to give other advantages single-phase outputs from 3,200 to 4,800 MVA at voltages from 66 to 380 kV can be obtained. To enable this to be carried out, much interesting plant has been designed and complete arrangements have been made for recording and analysing the test results as well as ensuring safety in operation.

Reyrolle's are well known as pioneers in the manufacture of a particular type of switchgear, the reputation of which has grown as the years have passed. Its development was largely due to the work of H. W. Cothier, who was also mainly responsible for the establishment of the first testing station at Hebburn.

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"PACKAGED" BOILER

Ten thousand "packaged" boilers of the type described in this issue have been made in the United States. The great expansion of the oil industry encouraged the use of a boiler designed so that it could be sited anywhere without special preparation, requiring only connections to be made for fuel, water, electricity and steam. In Britain, a boiler of this type has not previously been available. G.W.B. Furnaces, Limited, who have taken up manufacture, acted on the suggestion made in a productivity team's report: "There is need (in Britain) for the development of a type of self-contained automatically-controlled oil-fired boiler of the American "packaged" pattern to supply the heat requirements of commercial buildings and small industrial plants." The result is a boiler for which the makers claim, in addition to portability, an efficiency of over 80 per cent. from full load down to 20 per cent. of full load; exceptional compactness – half the space required for a conventional boiler; no requirement for a tall chimney stack; the ability to burn gas, or oils of a wide range of viscosities; a marked absence of smoke; and economy in the production of steam. Installation costs are low since no special foundations are required.

GEORGE STEPHENSON'S HOME

DIAL COTTAGE MAY HAVE TO BE DEMOLISHED

Dial Cottage at West Moor, near Newcastle-upon-Tyne, where George Stephenson lived from 1805 to 1823, may have to be demolished unless some interested person or body offers to take it over when the present lease expires in about two years' time.

An inscription over the door, below the sundial which gives the cottage its name, reads: "George Stephenson, engineer, inventor of the locomotive engine, lived in this cottage from 1805 to 1823; his first locomotive (Blucher) was built at the adjacent colliery wagon shops, and on July 25, 1814, was placed on the wagon-way which crosses the road at the east end of this cottage." The phrase "inventor of the locomotive engine" is, perhaps, an over-simplification; as the late Dendy Marshall remarked, Lardner over-stepped the mark in going so far as to bestow the title of Father of the Locomotive on George Stephenson, but there are good reasons for calling him its godfather.

It was during the years when Stephenson lived at Dial Cottage (he was born in 1781) that he designed his early engines, known as the Killingworth engines from the name of the colliery there, about seven miles north of Newcastle. Stephenson worked as brakesman at the colliery from 1805 to 1810, except for a short period when he was in Scotland. In 1810 he was appointed engine-man, and in 1812 he became the colliery engine-wright. According to Dendy Marshall, from whose book, *A History of Railway Locomotives Down to the End of the Year* 1831 (Locomotive Publishing Company) these particulars are taken, Stephenson started to build his first engine about September, 1813. He built four or five Killingworth engines – it is not known precisely how many – the design being characterised by vertical cylinders fixed in the top of the boiler and by return connecting rods. The Blucher had a gear drive but in 1815 he built a locomotive with crankpin drive. He experimented with steam springs to equalise the axle-loads, and with various ways of making wheels, and it was while he lived at Dial Cottage that he undertook the construction of Hetton Colliery Railway – the first railway to be made with the intention of using locomotives.

In 1819 Stephenson had apprenticed his son, Robert, to Nicholas Wood at Killingworth Colliery, and in 1823, the year he left the cottage, the firm of Robert Stephenson and Company was founded.

The National Coal Board are not expected to renew the lease of Dial Cottage when it expires. If the property then became vacant it would soon be derelict, since the owners are not prepared to take any action to preserve it. The present position is that notice has been served upon the owners and the lessees inviting them to attend a meeting of the local public health committee on April 20, when the future of the premises is to be considered. Should no appearance be made, the Longbenton Urban District Council could make a demolition order. The Council would be reluctant to do this but they are not authorised to spend rate-fund money on the maintenance of the cottage. There is no main water supply and no proper drainage system either to Dial Cottage or the adjacent Paradise Cottage. The roof also needs attention.

The County Planning Officer, and Mr. W. N. Lockey, the Council's Sanitary Inspector, who has been active in taking steps to prevent the cottage being demolished, consider that the best plan is to use powers under the Housing Act to draw the attention of interested persons or institutions to the position of the cottage. Mr. T. H. Webster, A.M.I.C.E., who has visited Dial Cottage recently, reports that a ruined workshop 100 yards behind the cottage still contains parts of an old wall drilling machine.

* * *

Letters to the Editor

TWO-STROKE GAS ENGINE OF 1881

SIR, As you know, March 31, 1954, is the 100th anniversary of the birth of Sir Dugald Clerk, F.R.S. In commemoration of the event this Museum is showing a coloured drawing of his two-stroke gas-engine of 1881, together with a portrait and particulars of the man and his invention.

I am writing to inquire whether you or any of your readers know of an engine of this type which is still in existence. Your kind help in locating such an engine would be much appreciated.

Yours faithfully,
C. ST. C. DAVISON

Science Museum,
South Kensington,
London, S.W.7.
March 26, 1954.

BALANCING A ROTATING DISC

SIR, In his letter in your issue of March 12 (page 323) Mr. Jennings has presented some equations deduced from the vector diagrams given in my article of February 19 (page 241). I wish to thank him for his interest and make a few comments on the method he proposes.

The first case your correspondent considers is that in which trial masses are placed at 180 deg. If the values of U, R_1 and R_2 are known it is shown that T may be calculated. Substitution in the initial equations then gives the value of $\cos\theta$. There are, however, two values of θ between 0 deg. and 360 deg. which satisfy this result. This ambiguity does not exist in the graphical construction given in my article, not because of any inherent advantage in that method, but because the data considered are the angles α and β, the measured differences in the phase angles of vibration.

An unambiguous solution from amplitude measurements alone requires the use of three trial masses giving U, R_1, R_2 and R_3. If your correspondent's suggestion is followed, a pair of equations must be solved to give the value of θ. For the case of trial masses arranged at 120 deg., the simplest pair is perhaps

$$\cos\theta = \frac{U^2 + T^2 - R_1^2}{2UT},$$

$$\sin\theta = \frac{R_3^2 - R_2^2}{2\sqrt{3}UT}.$$

The numerical calculations suggested are not difficult, but I am sure Mr. Jennings will agree that the graphical method is simpler to use in the practical situation. A particular advantage of the graphical method, which the algebraic method does not possess, is that any lack of coincidence of the construction arcs gives visual evidence of the uncertainty in the determination of unbalance, which is due to the inevitable errors in the measurement of U, R_1, R_2 and R_3.

Yours faithfully,
I. J. SOMERVAILLE

National Standards Laboratory,
University Grounds,
City-road, Chippendale,
N.S.W., Australia.
March 23, 1954.

* * *

MACHINE TOOL TRADE

M.T.T.A. Dinner

The annual dinner of the Machine Tool Trades Association was held at Grosvenor House, London, W.1, on Wednesday, March 24, under the presidency of Mr. R. D. G. Ryder, who was supported by Mr. H. P. Potts, vice-President, and Sir Lionel Kearns, Sir Holland Goddard, Mr. J. B. S. Gabriel and Mr. Robert W. Asquith, past Presidents. The principal guests were Lord Baillieu, K.B.E., C.M.G., chairman of the Dunlop Rubber Company, and Sir Miles Thomas, chairman of the British Overseas Airways Corporation. Lord Baillieu responded to the toast of "The Guests," proposed by the President, and, remarking on the absence of Sir Greville Maginness, past President, who was on a visit to Moscow, said that there was a general wish to see an improvement in trade with Russia. The machine-tool industry had done much to build up British trade. During the war, all commercial considerations had to be laid aside, but now the industry had the prospect of great advances, provided that the leaders on both sides placed national interests above merely sectional interests. It was his own experience, in the course of extensive travelling in other countries, that they all wanted to "buy British."

Sir Miles Thomas, in proposing the toast of "The Machine Tool Trades Association," said that a country could be judged by the development of its machine-tool industry. The Association was established for the purpose of cutting out foolish competition and had contributed greatly to the present health of the industry. He recalled that the President, Mr. Ryder, had been the leader of the machine-tool industry's Productivity Team which visited the United States. He hoped that East-West trade would grow, to the benefit of the industry and the nation. If it did not, other countries would naturally wish to set up industries of their own. Sir Holland Goddard, in his reply, complimented Sir Miles Thomas on the work that he had done for British Overseas Airways and observed that the Comet aircraft had given rise to less trouble per passenger-mile than any other passenger aircraft in the world, which was a great tribute to the British aircraft industry and to the de Havilland Company. That the machine-tool trade, after 20 good years, now found itself in a buyers' market was probably a good thing. They were now in a position to offer much better deliveries, but there was still a need for more highly-trained technical salesmen, and the directors should visit more overseas markets. There was severe competition from the machine-tool industry of the United States, and from Germany. Eleven million refugees had entered Western Germany from Eastern Germany, and they were working hard; as one of them had said in his hearing, "We are making sure that our bosses get their contracts." He was glad to add, however, that the exports to Canada in 1953 were ten times the figure for 1949.

The proceedings closed with an informal vote of thanks to the President, proposed by Sir George W. Turner, K.C.B., Permanent Under-Secretary of State, War Office.

FOAM NUISANCE IN SEWAGE WORKS

Effect of Synthetic Detergents

On May 12, 1953, the Minister of Housing and Local Government, the Rt. Hon. Harold Macmillan, appointed a committee to examine and report on the effects of the increasing use of synthetic detergents and to make any recommendations that seemed desirable with particular reference to the functioning of the public health services. The committee have recently published an interim report* in which they state that a full report can usefully be made only after extensive further investigations. The available evidence on the effects of synthetic detergents, it is concluded, is not sufficient to cause any immediate alarm. A nuisance is, however, caused at some sewage works, and there are more serious possibilities relating to the efficiency of sewage treatment, the condition of rivers, and the purity of water supplies.

Synthetic detergents currently in use are chemically stable and retain their foam-producing power when they pass through the sewers into sewage disposal works. At many sewage works foam is produced, sometimes to a height of several feet, during the stages of purification when aeration occurs, particularly where the activated-sludge method is used. At some works this foam causes danger to the operators, and when it drifts off from the works it is offensive to the neighbourhood. Further research is necessary before any of the methods for suppressing foam that have been tried can be recommended as generally practicable, economic and safe for adoption in the United Kingdom. At present, however, this problem is not sufficiently serious to justify alarm.

At many British sewage works, efficient operation is maintained only with difficulty, for various reasons unconnected with the use of detergents. If, therefore, the presence of synthetic detergents in the sewage has a deleterious effect on the quality of effluents discharged, there is cause for serious concern, particularly since many sewage works discharge their effluents into rivers which may be used for public water supplies. Moreover, some of the constituents of synthetic detergents are only partly removed during sewage treatment, so that substantial proportions of them are being discharged to rivers. The question arose whether they were present in sufficient concentration to harm river life or river-drawn water supplies.

CORROSION

Another question under investigation by the committee is the possibility of corrosion of domestic plumbing systems and household appliances by synthetic detergents. The possibility exists since the detergents may remove films of grease and soap curds. The committee consider, however, that the risk of corrosion to plumbing systems from this cause is not great if the sink is rinsed after each washing process.

The employment of easily corrodible metals and electro-chemically dissimilar metals in the same system should be avoided; such precautions may become more important with the increasing use of synthetic detergents. The problems relating to the corrosion of household appliances, the committee consider, are best left for solution by the manufacturers of appliances and detergents.

* *Interim Report of the Committee on Synthetic Detergents.* Ministry of Housing and Local Government, H.M. Stationery Office, Kingsway, London, W.C.2. (4*d.* net.)

FACTORY EQUIPMENT EXHIBITION

The second Factory Equipment Exhibition, sponsored by the proprietors of the "Factory Manager" and "Factory Equipment News," was held at the Royal Horticultural Society's Halls, Westminster, London, S.W.1, from March 22 to 26. The increase in the number of exhibitors in comparison with the first exhibition made it necessary for both halls to be used and next year the exhibition is to be held at Earls Court, London, where more space is available. The exhibition is held under the patronage of H.R.H. the Duke of Edinburgh, and Lord Rochdale, O.B.E., President of the National Union of Manufacturers, performed the formal opening ceremony.

A number of conferences were held during the exhibition. The sessions on Tuesday, March 23, and Thursday, March 25, took the form of discussions under the auspices of the British Productivity Council. On Wednesday, March 24, there were two discussion periods on the subject of "Management and Productivity" arranged by the London Branch of the Institution of Works Managers. The first session was to consider how productivity could be increased in this country by extended use of plant and equipment; machine processes; assembly operations; work movement; and simplification, specialisation and standardisation. The second session considered the effect of labour relations on productivity, particularly as influenced by the management structure; consultation, formal and informal; and incentives.

The exhibits displayed in both halls included office equipment, industrial clothing, mechanical-handling equipment, detergents, electrical controls and small tools.

SMALL HYDRAULIC CLAMP

Among the exhibits on the stand of Power Jacks, Limited, Valetta-road, Acton, London, W.3, was the Newton hydraulic plunger and a hand-lever and screw-down type of hydraulic pump. The hydraulic plunger has been designed for use as a clamp and may be incorporated in jigs and fixtures to hold the workpiece in position. Its outer cylinder is about 4 in. long by 1 in. in diameter. One or more of these plungers may be connected to either type of pump by $\frac{3}{16}$-in. outside-diameter tubing. The nose of the plunger can be fitted with a hardened button for bearing directly on the workpiece or may act through a system of levers and bell cranks. The stroke of the plunger is $\frac{1}{2}$ in. The lever-operated pump is capable of exerting a clamping pressure of 2,500 lb. per square inch and the screw-down pump of 1,500 lb. per square inch. This type of clamping should prove ideal for jigs and fixtures used in small batch production as it can be operated from a central point, thus obviating the need for a number of single clamping operations.

The Service Electric Company, Secomak Works, Honeypot-lane, Stanmore, Middlesex, were showing their range of Secomak Statair blowers designed principally for valve cooling in electronic equipment. They comprise an electric motor mounted on ball bearings and a centrifugal blower which has a fabricated sheet-aluminium impeller. The smallest model, recently introduced, No. 200, measures 4 in. overall by $3\frac{7}{8}$ in. by $3\frac{1}{4}$ in. The output is 10 to 12 cub. ft. of free air per minute, or 7 cub. ft. per minute at 0·2 in. water gauge. Its total weight is $3\frac{1}{2}$ lbs.

Included among the wide range of exhibits displayed by Salisbury Precision Engineering, Limited, Salisbury, Wiltshire, was the "Sherpa" Handraulic truck. It is the latest addition to their range of mechanical-handling equipment. In appearance it resembles a porter's two-wheeled hand barrow. Steel tube has been used in its construction. A platform which can be raised and lowered by a hydraulic ram has been incorporated in the truck to enable it to be used as a lift truck when standing on end. The pressure for operating the ram is obtained from a manually-operated pump installed directly below it. In the lowered position the platform rests against the front hoop of the truck. A maximum load of $2\frac{1}{2}$ cwt. can be raised 3 ft., which is the height of the tailboard on most lorries. The size of the lifting platform is 20 in. by 16 in.

A display by the British Electrical Development Association, 2 Savoy-hill, London, W.C.2, dealt with industrial heating and lighting. A working exhibit showed how infra-red heating is used to seal plastic Viskrings in bottle capping. The plastic sleeve is pushed over the bottle cap and neck, and then passes through a locally-heated tunnel where it is shrunk in position.

GAS-FIRED FURNACE

The centrepiece on the stand of The Gas Council, 1 Grosvenor-place, London, S.W.1, was a model of a gas-fired heat-treatment plant comprising four deep recuperative-furnaces which is used for the treatment of motor-car components. Coke-burning equipment was represented by a high-efficiency coke burner. The particular burner shown was the Suxe, a Swedish invention being made under licence in this country by the Hemel Hempstead Engineering Company, Limited, Hemel Hempstead, Herts. The burner is a completely water-cooled, independent unit, which can be fitted to any central-heating boiler. It is fully automatic, and has a 12-hour gravity-feed hopper.

Five different electric battery vehicles for industrial and other uses were shown by Brush Coachwork, Limited, Loughborough. The "Pony," a new vehicle with front-wheel springing designed for inter-works services and having a 25- to 30-mile range, was one of the exhibits. It is capable of carrying 20 cwt. at about 8 m.p.h. A larger model shown was the H.E.30, which can carry 2 tons. This model incorporates a platform, which can be elevated, measuring 3 ft. wide by 5 ft. 6 in. long.

Tubewrights, Limited, Egginton House, 25 Buckingham-gate, London, S.W.1, a subsidiary of Stewarts and Lloyds, Limited, who specialise in the design of fabricated tubular-steel structures, two examples of which were described in ENGINEERING, vol. 176, page 617 (1953), occupied one of the stands. Their main exhibits were a number of tubular-steel post pallets and the "Pallage," which permits the rapid building-up of various forms of mechanical-handling equipment such as a tray, crate, rack, pallet and stillage from standard components.

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RAILWAY TRACK MAINTENANCE

1,800 Miles to be Renewed

British Railways plan to carry out 1,821 miles of complete and partial renewals of track during 1954. Standard flat-bottom rails will be used for 923 miles of new track and bull-head rails for 449 miles, the remainder being partial renewals such as re-sleepering. In addition, 74 miles of conductor rails on electrified lines will be renewed.

The renewal programmes also include 136 bridges, 45 miles of new drains, and 244 miles of fencing and other line-side structures, as well as signalling and telecommunication equipment.

TIMKEN ROLLING-MILL BEARINGS

British Timken, Limited, Duston, Northampton, who have made a close study for a number of years of the application of taper-roller bearings to the roll necks of rolling mills, have recently added to their series of industrial films one entitled "Tapered Roller Bearings in Rolling Mills," which has been made available for general release.

It shows, in the opening sequences, some of the numerous uses for which steel, and especially steel sheet and strip, is employed in manufacturing industry and then proceeds to show various mills and other rotating machinery at work, for instance, in some of the factories of the Metal Box Company. The scene then changes to the works of British Timken, Limited, where the various stages in the production of large roll-neck bearings are shown in detail, with special emphasis on the accuracy of manufacture and the means adopted to ensure it, which are well explained in the accompanying commentary. The film is of the 16-mm. size and is 1,050 ft. long, on one reel. It runs for about 28 minutes. There is also a French version, and a German one is in preparation. Applications for the loan of the film, with or without the services of a technical representative of the firm to answer subsequent questions, should be made to British Timken, Limited, at the address given above.

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MANUFACTURE OF RADIO VALVES

Educational Film

With the co-operation of the Publicity Department and the Educational Service of Mullard, Limited, Century House, Shaftesbury-avenue, London, W.C.2, National Screen Services, Limited, have recently completed a film illustrating all the operations involved in the manufacture of a small modern radio valve from the raw-material stage to the final testing. A particularly interesting feature of the film is that some of the hand-assembly operations of the small components are shown very effectively by means of the slow-motion photographic technique. The film, which includes a sound track, has been prepared for exhibition to engineers, technicians and technical students, and is available for distribution to technical colleges, schools and technical and scientific associations. The running time is approximately 25 minutes. The film was shown to an invited audience on Tuesday, March 23, and full particulars of it can be obtained from the Mullard Educational Service at the above address.

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LIFT MAKERS' CENTENARY

This year marks the centenary of Pickerings, Limited, Stockton-on-Tees. Founded by Jonathan Pickering, the first product was the patent Pickering pulley-block, which was a great advance on hoisting gear then in existence. The firm has continued to manufacture hoisting and handling plant, and was one of the earliest in this country to make lifts. Self-sustaining hand lifts were followed by belt-power and hydraulic lifts until, in 1888, they made their first electric lift. A fully automatic push-button lift was constructed in 1896.

The company now make over 300 lifts a year at the Globe Elevator Works at Stockton. These are of all kinds and sizes, ranging from high-speed lifts in office blocks to ammunition hoists for coastal batteries. Handling plant and furnace-charging machines are also being made. Much of the output is exported abroad. In this country there are service stations in many of the large towns.

PERSONAL

H.R.H. THE DUKE OF GLOUCESTER, K.G., has consented to be Patron of the Society of Engineers (Incorporated), 17 Victoria-street, London, S.W.1, which celebrates its centenary this year.

MR. V. R. PREHN, M.I.Prod.E., works director, Ruston & Hornsby, Ltd., Lincoln, has been appointed assistant managing director. Mr. G. B. R. FEILDEN, M.A.(Cantab.), M.I.Mech.E., hitherto chief engineer, gas turbines, has been elected to the board as engineering director.

DR. A. S. MACLELLAN, B.Sc., M.I.Mech.E., and Mr. G. R. GRANGE, D.S.O., M.C., B.Sc., retired from the board of Alexander Stephen and Sons, Ltd., Linthouse, Govan, Glasgow, on March 31.

MR. G. R. EDGAR, M.Sc.(Durham), principal surveyor to Lloyd's Register of Shipping at Newcastle, is to retire in a few months' time, having now reached pensionable age. During his 40 years of service he has been stationed in Glasgow, London, Rotterdam, Belfast, Greenock and Newcastle. His successor at Newcastle is to be MR. H. P. URWIN, principal surveyor at Sunderland.

MR. HUBERT GREENWELL, editor of our contemporary, *The Colliery Guardian*, 30 and 31 Furnival-street, Holborn, London, E.C.4, since 1912, has retired after serving on the editorial staff of that periodical for 54 years.

MR. N. P. NEWMAN was re-elected chairman and MR. LEONARD GOULD, MR. F. D. LEY and MR. H. V. SHELTON were re-elected vice-chairmen at the recent annual meeting of the Council of Ironfoundry Associations, Crusader House, 14 Pall Mall, London, S.W.1. MR. T. LEE resigned from the executive committee of the Council on the grounds of ill-health and MR. A. D. MACKENZIE, O.B.E., B.Sc., was elected to fill the vacancy. The two retiring members of the executive committee, MR. ARTHUR WATSON and MR. D. GRAHAM BISSETT, were re-elected.

REAR ADMIRAL (E) ROBERT COBB, C.B.E., M.I.Mech.E., M.I.Mar.E., has been appointed to the staff of the science department of the British Council. He will take up his new post in May.

MR. SEBASTIAN Z. DE FERRANTI, the elder son of Sir Vincent Z. de Ferranti, has been elected a director of Ferranti Ltd., Hollinwood, Lancashire.

MR. J. E. BLACKSHAW, M.B.E., M.I.Mech.E., M.I.Prod.E., has relinquished his position as managing director of G. D. Peters & Co. Ltd., but is retaining his seat on the board and will be available in a consultative capacity.

MR. W. M. BENNETT, A.M.I.E.E., has been taken into partnership by Mackness and Shipley, consulting engineers, Parliament Mansions, Abbey Orchard-street, London, S.W.1.

Following the annual elections for 1954, the names of the officers of the Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.1 are: as President, MR. R. D. G. RYDER, as vice-president, MR. H. P. POTTS and as honorary treasurer, MR. G. E. HICKMAN.

MR. R. E. HAYLOCK, who for 33 years has been London-office manager of Dallow Lambert & Co. Ltd., process-dust control engineers, Spalding-street, Leicester, has retired. His successor in the office, at 20 Fitzroy-square, W.1, is MR. A. P. REEVE.

MR. ROBERT CRICHTON has retired from the position of managing director of Scottish Oils Ltd., after 58 years in the Scottish oil industry. His successor is MR. J. M. CALDWELL.

MR. W. A. CREWE, general manager of Delco-Remy-Hyatt, Division of General Motors Ltd., and a director of General Motors Ltd., has retired after 32 years of service, the last 15 of them as general manager of the Delco-Remy-Hyatt organisation.

The President of the Board of Trade has appointed MR. SAM BLACK, MR. J. CHALMERS BROWN, M.C., J.P., and MR. SYDNEY HARRISON to be members of the Scottish Committee of the Council of Industrial Design. LADY SEMPILL and MR. J. DOUGLAS HOOD have been re-appointed members of the Committee on the termination of their existing appointments.

Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, announce that their vacuum-products activities have now been merged with their new products department, which has been renamed the scientific apparatus department. The officers of the new department are MR. J. W. BUCKLEY, M.C., M.Sc., A.M.I.E.E., F.Inst.P., sales manager; MR. W. J. BROWN, B.Sc., A.M.I.E.E., assistant sales manager; MR. J. BLEARS, B.Sc.(Eng.), A.M.I.E.E., Assoc.M.C.T., chief engineer and MR. R. S. CLARK, A.M.I.Mech.E., A.M.I.Prod.E., assistant superintendent.

MR. J. F. WILLIS has been appointed representative for Scotland of Hopkinsons Ltd., Huddersfield.

MR. G. E. CATER has been appointed general sales manager of Tecalemit Ltd. He has recently returned from India where he was a director and general manager of Tecalemit (India) Ltd., and Tecalemit (Pakistan) Ltd., and deputy general manager of the managing agents, Heatly and Gresham Ltd.

MR. J. LEES has been appointed assistant home sales manager, Leyland Motors Ltd., Leyland, Lancashire. He will be stationed at the company's London office in Hanover-square, W.1.

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BUSINESS CHANGES

PANELEC (GREAT BRITAIN) LTD., electro-thermal engineers, announce that from April 20 their address will be 27 Hatchlands-road, Redhill, Surrey. Their telephone number, Redhill 3461, will remain unaltered.

THE BRISTOL AEROPLANE CO., LTD., Filton House, Bristol, inform us that the agreement between the Canadian Government and themselves covering the manufacture of military versions of the Bristol Britannia in Canada has now been formally concluded in Ottawa. The design modifications for the military role and the work of construction will be undertaken by CANADAIR LTD., of Montreal, with the Bristol Aeroplane Co.'s technical collaboration.

The Ministry of Materials announce that, as from April 23, the remaining duties of the DIRECTORATE OF NON-FERROUS METALS, at Rugby, will be taken over by the headquarters of the Ministry of Materials, Horse Guards-avenue, London, S.W.1, and correspondence should be addressed accordingly. MR. R. F. RUCKER, the present Director is retiring from the public service at the end of April.

MONKS AND CRANE LTD. have opened a new Manchester office and distributing centre at 8 Wilmslow-road, Manchester, 14. (Telephone: Rusholme 6224-5-6.)

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OBITUARY

We regret to record the deaths of the following:

SIR JOHN O. SANDERS, C.M.G., M.Inst.T., A.M.I.C.E., in London on March 21 at the age of 61. General manager, Malayan Railway, since 1946; member for Railways and Ports, Federation of Malaya, since 1951. Trained at L.N.W.R. locomotive works, Crewe. Gazetted C.M.G. in 1948. Created knight January, 1954.

REV. E. G. PALLOT, D.S.O., on Sunday, March 21 at the age of 77. Engineer Rear-Admiral, retired. Engineer manager H.M. Dockyard, Chatham, 1927 to 1932. Retired List 1932. Ordained in the Church of England, 1933.

MR. PETER BAXTER, at his home in Glasgow on March 19. Mr. Baxter, who retired three years ago, served for a long period as a director of Colvilles Ltd. and was also a former chairman of the Bent Colliery Co. Ltd., and of R. Y. Pickering & Co. Ltd. In 1939 he was seconded to the Ministry of Supply (Iron and Steel Control) and became liaison officer for Scotland and Northern Ireland.

MR. W. L. ALLARDYCE, at Hertford, on March 26, at the age of 56. He was appointed production manager, de Havilland Aircraft Co. Ltd., Hatfield, Hertfordshire, last year.

SIR STEPHENSON H. KENT, K.C.B., at the age of 81. Formerly chairman of Stephenson Clarke and Associated Companies Ltd., and a director of the Powell Duffryn Steam Coal Co., Ltd. In the war of 1914-18 he was director-general, Munitions Labour Supply and member of Council of the Ministry of Munitions. Hewas created a K.C.B. in 1917.

MR. H. V. BENNS, on March 26, at the age of 51. He was for many years on the staff of the control gear engineering department of the British Thomson-Houston Co., Ltd., Rugby. He joined the firm in 1917 as an engineering apprentice.

COLOUR-LIGHT SIGNALLING ON THE SOUTHERN REGION

On March 21, 1926, the then Southern Railway inaugurated its first colour-light signalling installation between Blackfriars and Holborn in London, while on March 21, 1954, the most recent installation between Norwood Junction, Selhurst and East Croydon, on the London Bridge and Victoria to Brighton lines, was brought into use. This last addition forms the third stage in a four-stage scheme which, as already recorded in ENGINEERING, will, when completed, provide this form of signalling between the two London terminals mentioned and Coulsdon North, where it will join the existing installation to Brighton. At the present time 435 track miles and 124½ route miles of multiple-aspect colour-light signalling are in operation in the Southern Region.

NEW SIGNAL BOXES

The present stage comprises two new all-electric signal boxes of Southern Region design, one at Norwood Junction with 107 levers and the other at Gloucester Road Junction, in the Selhurst-Croydon-Norwood triangle, with 131 levers. The former box will replace two manually-operated boxes with a total of 155 levers and the latter, which is a three-storey structure to enable the signalmen to observe the main through lines, replaces four boxes with 235 levers, thus making for more efficient control. The nature of the layout in this area of 4¾ route miles and 17¼ track miles is not conducive to automatic signals and there are, in fact, only six. The new all-electric signal box, to be provided at East Croydon in the fourth stage of the scheme is, however, already housing relay equipment, which is now operated from the existing manually-worked box at East Croydon North. This will facilitate the final conversion to colour-light signalling when East Croydon North and South boxes will be abolished.

SIGNAL ARRANGEMENTS

The area contains 80 multiple-aspect long-range signals and 23 junction indicators, the spacing being such as to provide a 2½ minutes head-way for stopping trains. The signals are carried on light-weight bridges or tubular steel posts with a gallery, the former being designed and erected by the Civil Engineer, Southern Region, while the latter were designed by contractors and erected by the staff of the Signal and Telecommunications Engineer's Department. There are also 36 floodlit disc-type shunting signals, which are solenoid operated, and 110 point machines, which are supplied from 120-volt batteries. These batteries are trickle-charged through rectifiers. Telephones are provided at all the automatic and most of the controlled signals to enable the train crews to communicate with the signal boxes. There are 175 condenser-fed track circuits, which incorporate 114 impedance bonds, this part of the equipment having been supplied by Siemens and General Electric Railway Signal Company, Limited.

The signal frames carry miniature individual levers, each of which is fitted with two magnets, one for interlocking and the other for track and indication locking. All the levers are also fitted with back or normal indication locks, but not with front or normal selection locks. Normal and reverse track locks are fitted to each point lever and the aspects of each signal are repeated behind its lever in miniature lights. The running and shunt signals have a "F" light behind their levers which show when they can be cleared, while behind each point lever is an illuminated "N" or "R" indicating the position of the points it controls. An illuminated diagram shows all the signals, points and track circuits controlled from the box and the presence of a train is also indicated. Magazine train describers are provided so that a signalman can advise an adjacent box of the class and destination of the next train.

The main contractors for the signalling apparatus were the Westinghouse Brake and Signal Company, Limited, York-way, London, N.1; Siemens and General Electric Railway Signal Company, Limited, Wembley, Middlesex; Metropolitan-Vickers General Railway Signal Company, Limited, Long Acre, London, W.C.2; Siemens Brothers and Company, Limited, Caxton House, Westminster, London, S.W.1; Tubewrights, Limited, Buckingham-gate, London, S.W.1; and W. R. Sykes Interlocking Signal Company, Limited, Clapham, London, S.W.4.

POWER SUPPLY

Electric power for the signal boxes is supplied through 27 miles of 3·3-kV three-core 0·2 sq. in. ring main which was manufactured by Pirelli-General Cable Works, Limited, 343 Euston-road, London, N.W.1. This firm also supplied 27 miles of 12-core pilot and supervisory cable, four cores of which are used in connection with the Translay system of feeder protection and the other eight for remote supervisory purposes. The ring main is connected to a substation at Waterloo, the output from which is controlled by three General Electric 25-MVA metal-clad truck-type oil circuit-breakers. A stand-by supply is also available from the South Croydon substation.

At each signal box the 3·3-kV supply is transformed to 480 volts and 240 volts single-phase and is then led through double-pole switch-fuses to a General Electric contactor arranged so that only one transformer is on load at a time. In the event of a failure of the transformer on load a stand-by is brought automatically into service. The operation of the 3·3-kV equipment is centralised by General Electric remote supervisory equipment which includes an illuminated diagram showing the condition of the circuit-breakers and which of the transformers is in use.

The change-over to the new system, which entailed the abolition of over 160 signal arms and fittings and a number of signal dolls and posts, was carried out within 6½ hours of line possession. Some 110 sets of points were also disconnected from the redundant signal boxes and re-connected to the new point machines.

FREIGHT MARSHALLING YARD FOR LONDON

£2,500,000 RAILWAY PROJECT

The Eastern Region of British Railways has recently received authority from the British Transport Commission to construct a new marshalling yard at Temple Mills, near Stratford, London, at a cost of £2½ million. The new yard will replace a group of out-of-date yards and will result in a general speeding up of freight traffic between London, East Anglia, the Midlands and the North of England and an estimated net saving of £150,000 a year.

Temple Mills, lying between two main junctions, Loughton Branch Junction and Lea Bridge Junction, at present comprises nine flat and one hump yard, the flat yards having, as a result of the design limitations of such yards, a capacity of only about 1,000 wagons a day. Dependent upon Temple Mills, and very largely doing work to relieve it, are six other yards in the locality, none more than five miles away.

The group of yards deal with traffic to and from nine distinct directions and almost every train conveys traffic for both forward and reverse directions. Present working is complicated, the existing yards having been built up and added to as a matter of expediency. Six of the ten Temple Mills yards, for example, receive virtually no traffic on direct trains, being fed solely by transfers from other yards. The uneconomic nature of the existing layout is illustrated by the fact that, though the total task, as represented by wagons moving into and out of the area, is something less than 5,000 a day, the total number of wagon-shunting movements made in the sixteen yards is not far short of 11,000. An added complication exists in that large numbers of empty wagons, many of special types such as banana and meat vans, have to be held to meet the fluctuating demands arising in the London Docks.

ELECTRIC POINT OPERATION

The new Temple Mills Yard will have twelve reception lines, six of which will be entered from either East or West. There will be 50 sorting sidings from twelve of which trains will be able to depart in either direction. Engine-release lines, brake-van storage lines, cattle pens and cripple-repair lines will also be provided, together with a servicing depot for turning round locomotives.

On the south side of the yard and parallel with the sorting sidings there will be five reception lines where down trains can be re-engined, re-crewed, or where traffic can be attached or detached. Allied to these reception sidings is a small hump which serves the southern-most twelve sorting sidings at the departure end of the main yard, in order to allow some secondary sorting of the express-freight trains to Cambridge, Whitemoor and Norwich.

The new yard at Temple Mills will have certain special features calculated to raise the speed of shunting. Beyond the crown of the main hump, for example, a release line is being provided to enable one humping engine to run clear so that a second train can be brought from the reception sidings and humped without waiting. Special attention has been given also to the layout at the inlet to the reception lines to avoid unnecessary manœuvring of humping engines.

Another principal feature will be the design of the gradients and the provision for braking in two stages by means of primary and secondary retarders. Advance in design in these respects is expected to reduce the unproductive time of the humping engines in closing up wagons from over 30 per cent. in the older yards to less than 10 per cent. The calculations on which this part of the design was based have been fully described elsewhere.*

The work now to be put in hand at Temple Mills will include new colour-light signalling, electric point operation, track circuiting and improved wagon-repair facilities. Land will be used on which the present yards are already sited and the new yard will be constructed under traffic. It is expected that construction of the new Temple Mills yards will take four years.

* R. E. Sadler, "Design and Equipment of Modern Marshalling Yards," Institution of Civil Engineers, Railway Division Paper No. 50.

NATURAL GAS IN PAKISTAN

A PROGRAMME OF INDUSTRIAL DEVELOPMENT

The existence of petroleum deposits in Northern Pakistan has been known for many years and those immediately to the west of Rawalpindi have been exploited for some considerable time by the Attock Oil Company, Limited. A feature of the existing oil wells is their great depth and the extremely high initial pressures which have to be dealt with. The existence, however, of natural gas in Baluchistan at a point about 600 miles to the south-west of Rawalpindi is a recent discovery.

This reservoir of natural gas has been located at Sui, which is 292 miles by direct air route from Karachi and 31 miles by road from the village of Kashmoor, the terminus of the narrow-gauge railway which branches at Jacobabad from the main line from Karachi to Quetta. The proved reserves of gas at Sui are estimated at 2,280,000 million cub. ft., which is stated to have the equivalent heating value of approximately 100 million tons of imported coal.

350-MILE PIPELINE

To meet the anticipated demand for Sui gas, Pakistan Petroleum, Limited, are to lay a 16-in. diameter pipeline as far as Karachi, and the route to be followed will pass through Sukkur, Hyderabad (Sind) and Jhimpir, the total distance being about 350 miles.

Fuel requirements by 1956 along this pipeline are estimated at 37 million cub. ft. of gas per day for power, and also for cement plants which are either already in existence or scheduled for completion by the end of 1955. The demand is expected to rise to 54 million cub. ft. of gas per day by the end of 1959, by which time spinning mills which are being installed at Hyderabad are expected to be in full operation. For the purpose of computation, therefore, the average daily off-take for the first four years of operation has been estimated at 45 million cub. ft. of gas per day.

On the basis of prospective fuel requirements, based upon electric power and general industrial development programmes which are scheduled for completion by 1963, the off-take reaches the estimated figure of 118 million cub. ft. of gas per day; the average off-take for the second period of four years of operation ending in 1963, has been estimated, therefore, at 86 million cub. ft. per day.

The cost of the pipeline has been put at £10 million for preliminary budgetting purposes.

EFFECT ON PAKISTAN'S ECONOMY

The effect on the economy of Pakistan will be considerable, since only inferior coal with a high sulphur content exists in West Pakistan and the oilfield of the Attock Oil Company, Limited, is by no means a major one. The great majority of the fuel requirements of Pakistan have, therefore, to be imported, and the saving in foreign exchange which is expected to result when the scheme is fully developed is estimated at £8·5 million a year on account of fuel alone.

The availability of Sui gas along the pipeline should stimulate agricultural and industrial developments, and an extensive increase may be foreseen in the lift-irrigation of areas not at present commanded by the great flow-irrigation schemes in Sind. Much of the country through which the pipeline will pass is extremely flat and only a few feet above the prevailing summer level of the Indus, and it seems that, apart from industrial applications, an increased demand for pumping plant and agricultural machinery will result from the availability of this natural gas.

The impact of this project on the economy of Pakistan is, therefore, likely to be considerable, as foreign exchange at present expended in the purchase of fuel will become available for other purposes, while the availability of this indigenous fuel will greatly facilitate the entire industrial programme of West Pakistan and will doubtless also make the lift-irrigation of certain otherwise scarcely cultivated areas a more practical proposition, thereby increasing the production of foodstuffs.

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POWER STATION EQUIPMENT

Orders and Deliveries

That orders for heavy equipment for power stations have not quite kept pace with production and that deliveries will have to be speeded up if the forecasts for the present year are to be achieved, are two of the conclusions of the sixth survey of member countries made by the Organisation for European Economic Co-operation. This survey gives the position concerning heavy equipment for power stations on October 1, 1953, and indicates future trends.

The lag in delivery and the shortage of orders were both greater in the case of thermal than in the case of hydraulic equipment but the volume of orders was showing a general improvement, mainly due to an increase in the demand for large-capacity sets. Indeed, this last was the general trend, the increased size of the sets and the advanced designs promising a higher efficiency in the plant. Delivery periods, too, had been improved and corresponded in most countries to the normal time for manufacture. The survey notes that the tendency recorded in the last report for consignments to exceed orders booked had been partially reversed, but there were still some doubts as to whether new orders would be received in time for manufacturers to be able to employ all available capacity during 1954 and 1955.

In the case of alternators for steam turbines, orders for machines below 40-MW capacity (covering deliveries up to March, 1957), while showing an increase, were still below deliveries during the period April and September, 1953, by 1,103 MW. For machines above 40 MW, the deficit was 389 MW. In spite of the increase of production capacity which is expected during 1954 and 1955, it was doubtful if the delivery forecasts made on April 1, 1953, could be fulfilled. The position for steam turbines was very similar but deliveries of plant over 40-MW capacity had fallen badly in arrears. Large turbine plant was mostly for home consumption, but much of the smaller plant was exported both to non-member countries and to overseas territories.

Boilers with capacities of 45 to 180 metric tons per hour also showed a decline in orders, this being partly due to the tendency to install larger plant. In the latter case, orders had exceeded deliveries, and almost all had been installed in the producer country.

In contrast to steam plant, hydraulic plant, both alternators and turbines, showed a large proportion of exports to non-member countries; exports in 1950 and 1952 were about one-quarter of the total but in 1953 had exceeded one-third. Deliveries were well up to schedule but orders for alternators were not keeping pace; orders for turbines were very slightly ahead.

The production of power transformers had shown a steady increase since 1950: deliveries for 1953 showed an increase of 69 per cent. Production capacity seemed fairly constant but delivery times had been reduced.

The tables at the end of the report show that on October 1, 1953, German delivery periods were quoted as about two-thirds those of the United Kingdom, with most other member countries lying in between. Germany was also building the largest sized sets (150 MW), and those working at the highest pressures (2,034 lb. per square inch).

Copies of the report (*Heavy Equipment for Power Stations.* Sixth Inquiry. O.E.E.C.), may be obtained from H.M. Stationery Office (3*s* .6*d*.)

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TECHNICAL EDUCATION IN LONDON

Extensions at Battersea Polytechnic

The facilities for higher technical education in London have been materially increased by the opening of new extensions to Battersea Polytechnic. The formal ceremony of opening was performed by H.R.H. The Princess Royal on Friday, March 26, in the presence of a large number of representatives of the London County Council, university and other educational authorities, and of industry. Accommodation has been provided in the new buildings for the departments of physics, electrical engineering and metallurgy as well as some other departments of the Polytechnic. The adaptation of rooms in the old building which have been vacated by these departments has enabled greater space to be made available for the departments of civil and mechanical engineering, chemical engineering, chemistry and mathematics. In all, the extensions have increased accommodation by more than half and the acquisition of premises in Putney formerly occupied by the Polish University has provided further space.

The cost of the new building, including furniture and equipment, has been nearly £385,000, the whole of which has been provided by the London County Council with the approval of the Ministry of Education. The architect for the extension was Mr. Owen Campbell Jones, F.R.I.B.A., and the main contractor, James Carmichael (Contractors), Limited, Wandsworth, London, S.W.18.

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DEGREE COURSE IN MINERAL DRESSING

Because of the growing importance of the operations involved and the necessity of training mining engineers in the application of scientific methods to processes which require a close control of physical and electrical forces and chemical reactions, the Royal School of Mines, one of the trinity of colleges forming the Imperial College of Science and Technology, has carried out a number of modifications to its laboratory space and concurrently initiated a new three-year course of undergraduate instruction in mineral dressing.

The new three-year course, entry to which requires a pass in, or exemption from, the London B.Sc. (Inter.) examination in chemistry, physics and mathematics, leads to the B.Sc. (Eng.) degree of the University of London and to the Associateship of the Royal School of Mines (A.R.S.M.). Post-graduate work, normally concerned with special research, will lead to the higher degrees of M.Sc. or Ph.D. or to the Diploma of the Imperial College (D.I.C.).

ARTS AND COMMERCE PROMOTED

BICENTENARY OF THE ROYAL SOCIETY OF ARTS

History is full of examples of men who " builded better than they knew," but of none can it be said more truly than of the small party, eleven in all, who, sitting in a London coffee house on March 22, 1754, resolved to found a society " for the Encouragement of Arts, Manufactures and Commerce "; for this was the beginning of the Royal Society of Arts, of which it has been said with truth that the life of every Englishman now living has been affected in some degree by its operations.

The coffee house was Rawthmell's, in Henrietta-street, Covent Garden; the site, within much less than the proverbial stone's throw of the office of ENGINEERING, is now occupied, with others, by St. Peter's Hospital. The eleven founders were, to quote the first minute-book of the Society, " the Right Honble. Lord Viscount Folkstone, the Right Honble. Lord Romney, the Revd. Dr. Steven Hales, Jno. Goodchild, Esq., Messrs. Lawrence, Baker, Crisp, Brander, Short, Messiter, & Shipley." The recorder of the minutes, I. Champion, who may or may not have been present in person at the meeting, evidently recognised a proper distinction in the title of " Esquire."

The prime mover in the gathering was the last man named in the minute — William Shipley (1714-1803), a drawing master from Northampton. He it was who conceived the idea of " raising by subscription a fund to be distributed in Premiums for the promoting of improvements in the liberal arts and sciences, manufactures, etc." He propounded his scheme in a leaflet, and followed this with another in which he went into more detail regarding the method of operating it. Support came very slowly, but two of the supporters were Lord Folkestone and Lord Romney, both men of influence, and, as stated, the society was duly formed. The first prizes offered were for the discovery of deposits of cobalt within the country, and for the cultivation of madder, with the intent to make the British dyestuffs industry self-supporting in its utilisation of these materials.

In its early days, the Society was not in a position to contemplate establishing its own headquarters. Only a few meetings were held in Rawthmell's coffee house before the venue was changed to a circulating library in Crane-court, Fleet-street; then it was moved to Peel's coffee house, at the corner of Fetter-lane and Fleet-street. The first permanent premises were in Craig's-court, Charing Cross, into which the Society moved in 1755, but these proved unsatisfactory and, in 1756, a house was acquired in Castle-court, off the Strand. By this time, however, the membership was increasing quite rapidly and in only two years it became clear that more commodious quarters were necessary.

A site was found in the Strand. It was occupied by a warehouse, which was demolished and its place taken by a building designed by William Chambers, the architect of Somerset House, which provided the Society with a " Great Room " for meetings and, beneath it, a " Repository " in which to store their models, etc. They entered into occupation in 1759 and, two years later, held in the Repository their first exhibition, of models and machines. The premises were only held on lease, however, and by 1770 they were becoming inadequate. It was then that the Adam brothers, who were developing the riverside site which has been known ever since their day as the Adelphi, offered to provide on it a more suitable headquarters, for a premium of £1,170 and a rent of £200 per annum. The offer was accepted and in 1774 the Society moved into the house which is still their home, and in which they have so liberally justified the legend which has surmounted it for 180 years — "Arts and Commerce Promoted."

The full story of that justification is much too long to be condensed satisfactorily in a page, but it is admirably related in the bicentenary volume which Mr. Derek Hudson and Mr. Kenneth W. Luckhurst* have compiled. It has been the main source in the preparation of this article, and is likely to stand as the definitive history of the Society for another century at least. In the arts, in agriculture, in manufacturing industry, in commerce, and in what might be termed broadly the promotion of the common weal, the Royal Society of Arts has a record of pioneering inquiry and active encouragement that is surely without parallel.

In many of its fields of interest, the Society was breaking entirely new ground in its early days, and did so with such good effect that other and more specialised bodies were founded to carry on the work. In some instances, when this occurred, the Society was content to allow the newcomers to undertake the further care of these activities; but its members continued to keep a watchful eye on the trend of events and were always ready with assistance and encouragement. For instance, the establishment of the Royal Academy in 1788 provided a new centre for the promotion of fine art; but the Royal Academy was not particularly concerned with the application of fine arts to industrial products, and the Society has continued to take a very practical interest in that field. A comparatively recent manifestation of this interest was the Exhibition of British Art in Industry, out of which developed the Council for Art and Industry, eventually succeeded by the Council of Industrial Design.

During its first century, however, the Society's chief claim on the attention of the historically-minded technologist or industrialist lies in its remarkable success in bringing to fruition an extraordinary variety of ideas and inventions that were adopted as real advances. Greathead's lifeboat, the harpoon gun for use in whaling, the chimney-sweep's brush, the mole-plough for draining land, what appears to have been the first gas mask – the invention of a miner – the telescopic fire-escape, and (an important advance, if hardly a technical one) the first " public convenience," are among the innovations that the Society sponsored.

Undoubtedly, however, the greatest single event in the Society's history was the Great Exhibition of 1851, and it may be said with assurance that it is the activity which has had the most widespread influence in the cause of British industry. The initial impulse appears to have come from Francis Whishaw, who was secretary of the Society from 1843 to 1845; he organised a small exhibition in 1844, in the present lecture hall of the Society, and repeated it early in the following year. Having thus prepared the minds of the members for the greater project that was in his mind – a " Grand Annual Exhibition of Manufactures " – he persuaded William (later Sir William) Cooke, joint inventor with Sir Charles Wheatstone of the electric telegraph, to submit a formal proposition to the appropriate committee. The proposal was adopted, Whishaw judiciously reported the fact to the Prince Consort (then President of the Society), and was " commanded . . . so soon as the plan . . . matured, to lay it before His Royal Highness."

The first " exhibition of select specimens of British manufactures and decorative art " was held in March, 1847, in the Society's house, where it was visited by more than 20,000 people. A second exhibition was held in 1848 and drew the remarkable total of 73,000 visitors. The third, in 1849, though deliberately limited to a few sections, was seen by about 100,000. These results, it was felt with some reason, justified the bolder venture of an exhibition on a truly national scale, which, it was decided, would be held in 1851. The responsibility for the Great Exhibition was taken over ultimately by a Royal Commission under the vigorous and able presidency of the Prince Consort and (to quote Mr. Hudson and Mr. Luckhurst) the Society " was undoubtedly eclipsed by the grandeur of its prodigious offspring "; but it was not so for long, and it still had as its President the indefatigable Prince Albert, who saw to it that the Society's part should not be forgotten. As a result (to quote again) " it . . . emerged from the exhibition year as an institution which had to be reckoned with in the public life of the nation . . ." and fortified " by the knowledge that, by its sole initiative and drive, it had rendered an outstanding service to the nation, and, indeed, to the world."

In the engineering field, the Society came to the forefront rather late, although within five years of its foundation it was offering prizes for improvements in windmills and tide mills, and several awards were made in connection with the design of water-wheels. In 1783, too, a prize was offered for means of " increasing the quality or force in steam engines with less fuel." That it was never claimed may have been due to the rule that patented inventions were not eligible. With the coming of industrial electricity, however, there was a remarkable difference in emphasis, for some of the most important advances were the subject of papers and demonstrations under the Society's auspices.

As early as 1849, electric lighting was exhibited in the Society's house, the lamps being, of course, battery-operated. In 1878, to illustrate a paper by J. N. Shoolbred, a Crossley gas engine was installed in the library to drive a Gramme dynamo, and a Brotherhood steam engine in the yard drove a Siemens dynamo. Thereafter, in 1882, a Crossley-Siemens set was permanently installed and the building was lighted by it until 1899, when a mains supply became available. Four years later, gold and silver medals were offered for the best prime movers for electric power generation, the gold medals being awarded to the Atkinson, Crossley and Griffin gas engines and to a Paxman steam engine.

In 1895, Professor Vivian Lewes, in a lecture to the Society, made the first public announcement of a process for the commercial production of calcium carbide. Tramways had engaged the attention of the members as early as 1857 – three years before the first public system was opened in Birkenhead.

In maritime affairs, the Society has long been closely concerned, from the points of view of both safety and efficiency. A prize for a method of combating the ravages of the teredo in ships' timbers was offered in 1757, extensive tests being made not only in home waters, but also in the West Indies and in North Carolina. Comparative tests of the stiffness of ships, and of improved forms of underwater form, were carried out in considerable detail, and the Society was actively engaged in the tank-testing of hulls as long ago as 1762. Similar tests were made for mechanically-propelled canal boats.

Latterly, activities in connection with ships have been associated mainly with the bequest of Thomas Lowe Gray in memory of his father, Thomas Gray, a former Assistant Secretary of the Board of Trade and composer of the rhyming " Rule of the Road at Sea." The bequest, of £10,000, was received in 1925, and has enabled the Society to perform some very practical work in furthering the science of navigation and promoting the interests of seafarers generally.

These instances that have been given of the Society's beneficial activities are but typical of the many directions in which it has carried out the aims of its founders. In the words of its present President, H.R.H. the Duke of Edinburgh, " By its persistent and unobtrusive activities, the Society has been an agent behind many notable developments, the good effects of which are felt to-day." That this good work will continue in its third century is certain, for, as in all scientific development, the more that is done, the more numerous are the openings for further advances,

* *The Royal Society of Arts*, 1754-1954, by Derek Hudson and Kenneth W. Luckhurst; with a Foreword by H.R.H. the Duke of Edinburgh, K.G., and an Introduction by the Earl of Radnor, K.C.V.O. John Murray (Publishers) Limited, 50 Albemarle-street, London, W.1. (30*s*. net.)

BOOK REVIEWS

Steel Pipes for Water, Gas, Sewage and Air. *Stewarts and Lloyds, Limited, Brook House, Upper Brook-street, London, W.*1. (Available on application.)

This volume is far more than a "catalogue," though that is how the Company concerned describe it; it is, in fact, sufficiently comprehensive to warrant the description of "treatise." As a catalogue, it does contain the numerous tables of dimensions, tolerances for all classes of all manner of steel pipes and special fittings suitable for the conveyance of gases, fluids and solids in varying degrees of suspension. There are also, however, notes on the installation of pipes and on their internal and external protection as well as their general maintenance and a brief description of the half-dozen possible methods of manufacture. But also, and justifying the description of treatise, the book contains some monographs on the strength of steel pipes and on the flow of liquids and gases along them.

These monographs give the appropriate formulæ – derived where necessary – and, for convenient use in the design office, the formulæ are represented in the form of graphs or nomograms. The section relating to the strength of pipes is divided into three parts: the strength when the pipe is subjected to either the bursting effect of an internal pressure or the collapsing effect of an external pressure and, thirdly, to the strength of pipes as simply-supported beams in either air or water and carrying either liquids or gases. The permitted stresses due to the combined effect of pressure and bending are limited to one quarter of the minimum tensile strength of the material, the equivalent maximum stress being derived on the basis of Haigh's maximum strain-energy theory as a criterion of failure under such conditions of load.

Test and Certification of Intrinsically Safe Electrical Apparatus. Testing Memorandum No. 10 (revised), Ministry of Fuel and Power. *H.M. Stationery Office, Kingsway, London, W.C.*2. (6*d*.)

This is the second edition of the memorandum issued in 1946 the scope of which has been enlarged. It will govern the official testing of all apparatus designed for use in coal mines and factories where there are hazardous conditions. The range of inflammable gases for which certificates may be given has been increased to include the following: methane, pentane, hexane, heptane, acetone, benzene, cyclohexane, carbon monoxide, hydrogen, coal gas, coke-oven gas and blue water-gas.

The memorandum has three parts and seven appendixes. Part I gives the definitions of "intrinsically safe," Part II the requirements, and Part III the procedure for certification. Five appendixes cover the principle of intrinsic safety, the gases included, the tests to be applied for all apparatus and the specific conditions for bell transformers. The last three deal with information required, registration and scale of charges.

Electrical Trades Directory. *Benn Brothers, Limited,* 154 *Fleet-street, London, E.C.*4. (50*s*.)

The latest edition of this useful publication, which for many years was known as *The Electrician's Blue Book*, contains 62,000 references to 13,000 firms on 1,539 pages. It therefore illustrates the growth and importance of the industry which it serves, a growth which is further illustrated by its own increase in size since it was first published over 70 years ago.

As has been the practice in recent years, the contents are arranged in 13 sections covering manufacturing companies, merchants, contractors, wholesalers and distributors and engineers, as well as information relating to supply, institutions, educational establishments and Government and municipal departments. A useful feature is a concluding section giving a list of the trade names used by the electrical and allied industries with descriptions of the products concerned. Reference to the various sections is facilitated by the provisions of guide cards. There is no doubt that the directory will be as constantly used during the coming year as it has been in the past.

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BRITISH STANDARDS

The following publications have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2 Park-street, London, W.1, at the price given after each title.

Copper Capillary and Compression Tube Fittings. (B.S. 864, 4*s*., post free, and B.S. 2051: Part 1, 3*s*., post free.)

Two standard publications dealing with copper and copper-alloy tube fittings with capillary and compression-type joints have now been published. The first, B.S. 864, is a revision superseding the 1945 edition. It applies to the most commonly-used types of fittings of nominal sizes ranging from $\frac{1}{8}$ in. to $2\frac{1}{2}$ in. The second, B.S. 2051: Part 1, is a new standard relating to three types of tube fittings for engineering purposes, of sizes ranging from $\frac{1}{4}$ in. to 1 in. Both specifications are concerned with three types of tube fittings, namely: (*a*) capillary fittings in which the joint is made by the flow of solder by capillarity along the annular space between the outside of the tube and the inside of the socket fitting, the size of this annular space being dimensionally accurate within close limits; (*b*) compression fittings, type "A" in which the joint is made by the compression of a ring or sleeve, or part of the fitting, on to the outside wall of the tube; (*c*) compression fittings, type "B," in which the joint is made by the compression of a manipulated portion of the tube, at or near its end, against a face of the body of the fitting or against a loose ring or sleeve within the fitting. Neither publication attempts the complete dimensional standardisation of any of these types of fittings, since the variety in the designs and methods of production already established by the various manufacturers makes any such attempt impracticable.

Insulating Sheets (Thermosetting Synthetic-Resin Bonded-Paper for Use at Radio Frequencies). (2*s*. 6*d*. post free.)

A further standard in the series dealing with synthetic-resin bonded-paper materials for use as electrical insulation has now been issued. This, B.S. 2076, specifies the requirements for two types of natural-coloured thermosetting synthetic-resin bonded-paper sheets between $\frac{1}{64}$ in. and $\frac{1}{4}$ in. thick, intended for use at radio frequencies up to and including 30 Mc. per second. In this respect it is complementary to B.S. 1314 : 1946, B.S. 1885 : 1952 and B.S. 1951 : 1953. The electrical and physical properties specified include power factor and permittivity, insulation resistance, electric strength along laminæ, water absorption and shear strength. Machining and punching tests, the latter for piercing and blanking, are also laid down. Methods of test to check compliance with the specification are fully described in appendixes which include appropriate drawings.

Farm and Horticultural Electrical Installations (Code of Practice). (15*s*., post free.)

The Council for Codes of Practice for Buildings, Construction and Engineering Services, Lambeth Bridge House, London, S.E.1, have issued, in final form, Code 325, which deals with farm and horticultural electrical installations. The provisions of the Code cover farm buildings, nurseries, market gardens and private gardens and are applicable both to new installations and to the modernisation and extension of existing installations. The publication points out the need for liaison at the planning stage between all parties concerned in order to determine the location of the main controls and the layout of the consumer's distribution in the light of the immediate applications proposed and possible future extensions. It surveys the operating conditions to which installations may be subjected and deals with earthing, battery-charging and the provision of electric fences. Sub-sections of the main Code relate to systems for the distribution of power; the design, construction and maintenance of wiring installations; lighting in and around farm buildings; the application of electric heating in farming operations; the selection, control and installation of electric motors and the heating of glasshouses and frames, soil-warming and similar applications.

TRADE PUBLICATIONS

Fork-Lift Trucks. We have received an eight-page illustrated leaflet describing the Hyster YT-40 fork-lift truck, made by the Hyster Company, 2902 N.E. Clackamas-street, Portland 8, Oregon, U.S.A. The YT-40 has a capacity of 4,000 lb., runs on pneumatic tyres and is fitted with trunnion-mounted steering. Three models are made: a low-lift model for passing through doorways, having uprights 65 in. to 74 in. in height; a standard model with 83 in. uprights; and a free-lift model with hoisting gear and uprights giving lifts of 8 ft., 10 ft. and 12 ft.

Mobile Cranes. Ransomes & Rapier Ltd., Waterside Works, Ipswich, have sent us a four-page illustrated leaflet giving a detailed account of the construction and performance of their 5-ton mobile crane; its American rating is 15,000 lb. Either a Perkins P.4 Diesel engine or a Morris M.E.B. industrial engine can be installed. The rear wheels, fitted beneath the cab, have a 90-deg. lock to enable the crane to turn within its own length. Separate electric motors drive the hoisting derricking and slewing gear. The crane is built to B.S. 1757 : 1951, and its road speed is $6\frac{1}{2}$ m.p.h.

Ultra-High Speed Photography. A leaflet issued by Winston Electronics, Ltd., 1 Park-road, Hampton-hill, Twickenham, Middlesex, describes the uses and capabilities of a high-speed photographic unit which can make exposures of 0·1 micro-second duration at a repetition rate of 20,000 per second. The unit uses an image converter and can also act as a stroboscope.

Process Timer. A cam-operated process-timer is described in a leaflet issued by the Electrical Remote Control Co., Ltd., Eastern Industrial Estate, Harlow New Town, Essex. Driven by a synchronous motor, it can have up to 120 cams controlling 240 circuits with a timing accuracy to within 0·3 per cent. in standard models or within 0·01 per cent. if specially required.

Reed-Type Tachometer. A leaflet describing a Frahm-type reed tachometer has been issued by Davis, Wynn and Andrews, Ltd., Cheltenham. The standard model has 31 reeds covering the range 1,000-4,000 r.p.m.; other sizes can be supplied. Rigid attachment to the machine is not essential.

Electronic Counter. Davis, Wynn and Andrews, Ltd., Cheltenham, have issued a leaflet describing their electronic counter. Mains operated, this instrument can count up to 5,000 pulses per second; the pulse input is 10 volts peak, but can be varied within fairly wide limits.

Transformers. To celebrate the fiftieth year of their foundation (ENGINEERING, vol. 176, page 471, 1953), Foster Transformers, Ltd., South Wimbledon, London, S.W.19, have issued an illustrated brochure giving the history of the company and its present range of products.

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BOOKS RECEIVED

Statistical Theory of Extreme Values and Some Practical Applications. A series of Lectures by EMIL J. GUMBEL. United States National Bureau of Standards, Applied Mathematics Series No. 33. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (40 cents.)

Fundamentals of the Working of Metals. By G. SACHS. *Pergamon Press, Limited,* 242 *Marylebone-road, London, N.W.*1. (30*s*.)

Polymer Degradation Mechanisms. United States National Bureau of Standards Circular No. 525. Proceedings of the NBS Semicentennial Symposium held on September 24-26, 1951. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (2·25 dols.)

Maintenance of Automatic Telephone Exchanges. Report of a visit to the U.S.A. in 1953 of a Productivity Team representing the British Post Office Engineering Department. *British Productivity Council,* 21 *Tothill-street, London, S.W.*1. (5*s*. 6*d*.)

Intermediate Engineering Drawing. By A. C. PARKINSON. Fourth edition. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (10*s*. 6*d*.)

Applied Descriptive Geometry with Drafting-Room Problems. By FRANK M. WARNER. Fourth edition. *McGraw-Hill Book Company, Incorporated,* 330 *West* 42*nd-street, New York,* 36, *N.Y., U.S.A.*

(4 dols.); and *McGraw-Hill Publishing Company, Limited, McGraw-Hill House, 95 Farringdon-street, London, E.C.4.* (32*s.*)

Formulas for Stress and Strain. By RAYMOND J. ROARK. Third edition. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (8·50 dols.); and *McGraw-Hill Publishing Company, Limited, McGraw-Hill House, 95, Farringdon-street, London, E.C.4.* (53*s.* 6*d.*)

British Diesel Engine Catalogue. Edited by D. S. D. WILLIAMS. Third edition. Published for the British Internal Combustion Engine Manufacturers' Association by the *Temple Press, Limited, Bowling Green-lane, London, E.C.1.* (52*s.* 6*d.*)

Report on the Collapse of Clifton Hall Tunnel which occurred on 28th April, 1953, at Swinton, near Manchester, in the London Midland Region, British Railways. Ministry of Transport and Civil Aviation. Railway Accidents. *H.M. Stationery Office, Kingsway, London, W.C.2.* (1*s.* 9*d.*)

Wege zur wirtschaftlichen Fertigung im Arbeitsmaschinenbau. By PAUL LANGE and WERNER ROSSBERG. *W. Girardet, Gerswidastrasse 2, Essen* (22*a*). (28·80 D.M.)

Energy in the Future. By PALMER COSSLETT PUTNAM. *D. Van Nostrand Company, Incorporated, 250 Fourth-avenue, New York 3, N.Y., U.S.A.*; and *Macmillan and Company, Limited, St. Martin's-street, London, W.C.2.* (90*s.*)

POWER SYSTEM PERFORMANCE

ANALYTICAL INVESTIGATION OF PLANNING AND OPERATING PROBLEMS

By C. P. Storr, M.A., M.I.MECH.E., M.I.E.E.*

Power system analysis has been discussed at length in the technical press, and many articles have been written on the relative merits of network analysers, analogue computers, digital computers and other means of expediting the work of investigation. The operating engineer is, however, not so much concerned with methods as with results. It is therefore desirable to consider the nature of the problems arising in planning and operating a power system and the advantages of making an analysis of performance.

A power system comprises one or more generating stations linked through a transmission system to transforming stations at load centres, the whole being planned to generate electrical power and supply it to the consumer as economically as possible consistent with reliability.

The two considerations, economy and reliability, are to some extent incompatible, but while the cheapest scheme would probably fall far short of giving reliable supply, a better system performance does not necessarily involve increased cost (either initial or running). A rigorous analysis of a proposed system may in fact show that improved performance can be achieved without increase in cost, or that the cost can be reduced without any loss of reliability.

In general, however, the plan finally adopted for a power system represents a compromise between economical and technical performance, giving the best possible performance that is economically justified.

The criteria of reliable supply to the consumer are: continuity (freedom from interruptions); maintenance of voltage within reasonable limits; and avoidance of excessive transient voltages, which may cause damage to apparatus.

CAUSES OF UNRELIABILITY

The principal causes of unreliability are: loss of synchronism between parallel running plant under normal conditions (steady-state instability); loss of synchronism following a system fault or disturbance (transient instability); system faults, causing fluctuations in voltage and/or frequency and also interruption to supply; excessive voltage variation with change in load on the system; high transient voltages during system faults, following switching operations, or induced by lightning phenomena – resulting in failure of plant; and failure of plant, either interrupting the supply or (owing to reduced availability) necessitating restriction of load.

While it is not possible to prevent system faults, particularly on overhead lines, the system layout can be arranged and the plant specified in such a way that the effect of the fault is minimised. Also, while failure of plant cannot be entirely eliminated, its probability can be reduced if the conditions prevailing on the system are accurately known and the plant is designed accordingly. Rigorous analysis of the system performance under various conditions enables its behaviour to be accurately predicted and plans and specifications prepared to ensure satisfactory performance. It may, of course, be found that the cost of incorporating all the features required for complete reliability will be so great as to be not economically justified. In such a case, a simpler system would have to be adopted with known limitations in performance – but with the advantage that as the limitations are known, operating procedure can be laid down to deal with the situation. For instance, if it is known that in certain circumstances the system can become unstable but the cost of installing an additional tie line cannot be justified, it is possible to arrange to split the system deliberately when required.

PLANNING A NEW SYSTEM

The need for investigation arises, therefore, when a new system is being planned in order to determine the best layout and to draw up specifications for the plant. Investigation is also necessary when extensions are being planned and, of course, when it is required to ascertain the causes of operating difficulties with an existing system. Had an analysis been made in the first place such investigations should not, of course, be necessary; they are nevertheless very frequently required as many systems have been commissioned without any preliminary analysis, either because its advantages were not appreciated or because it was planned before the present methods of analysis were available.

In theory, it is possible to calculate the performance mathematically, but in practice such calculations, even when permissible simplifying assumptions have been made, are so involved that they become tedious and protracted. Various means have been developed to eliminate these calculations and enable results to be obtained rapidly and with sufficient accuracy.

Various factors other than system performance affect the final decision on system layout and plant specification. These include the location of the power stations and load centres and the routes of the transmission lines, which are determined largely by geographical and economic considerations. In general, therefore, a preliminary layout is prepared before the system performance is investigated, and the object of the investigation is to determine whether the proposed layout is suitable or involves any limitations in performance. If analysis indicates that difficulties in operation will arise with the proposed layout, alternatives can then be investigated.

If the full benefit is to be derived from a system study, account must be taken not only of the conditions immediately arising but also of future development. It is therefore necessary to make reasonably accurate forecasts of the load growth and to determine the location of future power stations, so that system performance can be predicted for five or ten years ahead. A further study may of course be necessary in five years or so, particularly if the growth of load has not followed expectations.

EFFECT OF INTERCONNECTIONS

So far, consideration has only been given to the problems arising in individual systems running independently, but increasingly systems are being interconnected in order to minimise the standby plant required or to improve load factors where the peak loads do not coincide. Interconnecting lines may be long, and close control of the exchange of power on them may be essential if instability is to be avoided during normal running. In many cases a slight change in the governor setting or voltage on one system may result in a large change in the power or reactive kilovolt-amperes carried by the interconnector. On the other hand, apart altogether from stability considerations, it is frequently desired to keep the power interchange between systems within fairly close limits. In many cases, therefore, the method of system operation and control may be determined more by the interchange of power on the interconnectors than by the loading inside the system itself. The performance of the system when running interconnected with other systems can also be predicted by analysis, and a suitable operating procedure or means of automatic control planned.

If operating difficulties are experienced after a system has been commissioned, it is almost inevitable that the cost of carrying out modifications (even if these are possible) to eliminate the troubles will be very much higher than that of incorporating similar features in the first place. In many cases the latter would have involved no additional costs.

PREDICTION OF PERFORMANCE

The advantages of having an analytical study of the proposed system made in the planning stages may be summarised as: the performance of the system under various conditions can be accurately predicted; if any operating difficulties are disclosed, a means of removing them can be determined, and its cost assessed; the cost of investigation is trivial compared with the value of the information provided or the possible cost of carrying out modifications after the plant is installed; the investigation can determine, for example, the operating voltage to be used; the range of tapping adjustment to be provided; the sizes of synchronous condensers to be specified, and where they should be located; the breaking capacities required for the switchgear; the insulation levels to be specified; the line charging capacity to be specified for the generators; the type of protective gear required; and the amount of system operating losses.

Moreover, if an investigation of a power system is to give the best results it must be carried out by engineers who have made a special study of the problems involved and have access to records of experience on many systems. It is for this reason that the company with which the author is connected has formed a Power Systems Engineering Department which has available the most modern methods of computation.

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PREVENTIVE MAINTENANCE OF OIL ENGINES*

By H. D. Adam, A.M.I.MECH.E., M.I.MAR.E.

Mechanical breakdowns can be annoying, dangerous and may involve complete wreckage, according to circumstances, but they should invariably be educational. This paper has been written to put forward methods of maintenance that conduce to the avoidance of breakdowns, for very few serious accidents occur when the plant is properly maintained.

Points which should consistently receive attention include maintenance of smooth working conditions, avoidance of high maximum pressures, bad combustion, unequal loading of cylinders, and excessive exhaust temperatures. Starting and stopping should be done with care, not just according to a blind routine. The good condition of crankshafts and connecting-rod bolts is essential for sound working. Suggestions are made as to causes of cracked cylinder covers. The damage and failures that may occur due to excessive lubricating-oil temperatures are considered in conjunction with the reduction in bearing clearances that can be given.

THE CRANKSHAFT

The importance of maintaining correct alignment of the crankshaft is mentioned in most instruction books, and a description is usually given of the method of checking for correct alignment by testing the deflection between crankwebs when rotating the shaft. The maximum allowable deflection between the webs on medium-size engines is often given as 0·003 in. The weight of the piston and connecting rod under static conditions is often insufficient to deflect the crankwebs to the degree mentioned as admissible by manufacturers, and the shaft will certainly not make contact with any badly worn bearings. To ascertain its true running position, therefore, it must be forced into contact with all bearings.

The best way is to remove a valve and insert a piece of soft wood above the piston, of such a size that it is compressed by the piston when on top centre. The crankshaft alignment indicator is set to give zero reading with the piston on bottom centre. On putting the piston on top centre, compression of the wood forces the crankshaft into its bearings, and the maximum deflection, as obtained under running conditions, is recorded.

The practical engineer-in-charge knows he cannot always detect an overheated main bearing in an enclosed type engine. Bearings which have run out have been detected by using the above means for alignment checking. The crankshaft deflection was such that the crankshaft would have broken, if continued use had been made of the engine. The lack of alignment of the crankshaft can often be detected by knocks on main bearings, or untrue rotation of the flywheel.

Precautions must also be taken to avoid critical torsional or lateral vibrations, which occur if a change is made in plant driven or any alteration in speed. In some cases, engines are fitted with torsional vibration dampers; these must be kept in good working order.

CONNECTING-ROD BOLTS

The modern well-designed alloy-steel connecting rod bolt, if not subjected to a higher stress than the normal working stresses, need not be replaced during the working life of the engine, though most manufacturers recommend that connecting-rod bolts should be renewed after a period of running hours. The time given varies between 10,000 and 30,000 hours, regardless of the speed of the engine. This is a safety precaution and is advisable if the plant is not running under the supervision and periodic inspection of well-trained engineers, as there are many ways in which a bolt may be fatigued and caused to fail by the starting of hair cracks at roots of threads, which are often too sharp.

After any piston seizure, bolts should be renewed, as in these circumstances they must be subjected to excessive stresses, not being designed to stop the flywheel rotating and at the same time to absorb the forces being developed by combustion in other cylinders. Often, when connecting-rod bolts have fractured, there is a previous history of piston seizure.

To obtain rigid bearing surfaces, not subjected to deflections, it is recommended that only one thick, accurately machined compression shim should be used between the bottom end and the connecting-rod flange. A number of thin steel plates are often found, as this is the easiest way to adjust compression; these become dirty and bruised, and can never be made equivalent to a solid shim. In all cases, where it is considered bolts have been subject to the above mentioned or any other abuse, they should be renewed.

Despite all precautions, bolts have fractured, and in most cases the resultant damage has wrecked engines. This has undoubtedly been due to the shank of the bolt dropping and fouling the crank chamber, causing the bearing to be torn off the foot of the connecting rod, and all loose parts, connecting-rod included, to come in contact with the rotating crankshaft thereby often bending it and fracturing the cast-iron bedplate and cylinder casing. To avoid this damage, set screws through the bearing on to the bolt surface, to prevent the bolt dropping, should be fitted. This is considered an unnecessary precaution by those who have not experienced trouble. Apart from the avoidance of serious breakdown, the set screws are of use in holding the big end together when a piston is removed for cleaning.

With very small bearing clearances and cool lubricating oil, no fracture of white metal linings will occur. Of course, it is essential that the whole system be properly charged with lubricating oil before starting. If bearings are supplied with cool clean oil at the correct pressure, and clearances are kept small by removing shims when required, they will last for many years. There is no good reason for disturbing a big-end bearing if it does not show signs of excessive wear or overheating.

THE PISTON

When an engine has been standing for some time the lubricating oil drains away, and the engine must be turned and the piston lubricated before starting. In many cases, some lubricating oil gets trapped on the piston face or between the rings, so that merely casual care in lubrication may, for a time, be looked upon as sufficient; but the day comes when the piston is dry and seizure occurs.

Another cause of dry, and even rusty, cylinder liners is the dangerous practice of having a common exhaust system for more than one engine. The exhaust gases will invariably leak through any stop valve and get into the cylinder of a standing engine, through an open exhaust valve, and cause corrosion. One way of avoiding this trouble is to blank off the exhaust with a stainless-steel blank flange between the pipe joints.

Some modern engines are not fitted with separate cylinder lubrication through quills, in which case the cylinders receive only a minimum of lubrication by leakage from floating gudgeon pins. The cheapest and best method of ensuring lubrication on starting is to have one or two quills which can be connected up to the main lubrication circuit during starting, sufficient lubrication being obtained by splash under running conditions. Excessive piston lubrication is a frequent cause of high lubricating-oil consumption and stuck rings; this can be controlled by the use of suitable scraper rings.

PISTON RINGS AND RING GROOVES

If piston rings are placed near the top of a piston they are liable to get unduly hot and stick fast in the grooves. The ring, even when well placed, is often tight against the cylinder wall, but gases leak past between the lower piston-ring face and the land on the piston. A good valve face between piston ring and piston is often non-existent, resulting in gases leaking past and carbon being retained behind an overheated ring. A ring may be stuck in its groove when a piston is removed, but if it is bright all round it is doing its job, because, under working conditions, the piston is hotter than the ring, thus giving it a sufficient clearance to move.

Stuck rings have black faces and are hard to remove. The lower land on a piston-ring groove can be damaged by cutting out a stuck ring with a chisel. The best method of removing such a ring is to drill a hole about 2 in. from a free end and to crack it off by the use of a taper pin. It is then possible to get behind the ring with a soft chisel. No hard steel tools or files should be used to clean out ring grooves.

Many piston-ring grooves have sharp corners at the root; this has caused lands to break off and even the top of the piston to crack off in some cases. A new ring can be filed to a radius on the inner corners to avoid contacting the ridge, and this is usually done by skilled fitters. To be sure the ring fits properly, it should be closed into the running position, rubbed on the piston face and subjected to a light test.

Due to wearing-in, pistons, rings and cylinder liners make gastight working faces, so renewal of all piston rings at one time is a mistake. In oval liners, piston rings become oval due to wear, and when re-assembled they should be placed in the original position to ensure the continuance of gas-tightness. The useful life of a badly worn or an oval liner can be increased by the use of double-seal rings, if they are placed in the grooves the right way up, to form a double seal on the lower land of the groove.

Piston slap can be reduced by making a ring which fits tight in the top groove and stands proud of the piston, but allowing the original running clearance between piston and liner at the point of minimum wear. This acts as a top guide for the piston, keeps the rings steady in their grooves and protects them from combustion gases. Piston slap does little damage, but the noise so made might also be caused by dangerous slackness of some other part or by bad combustion.

The care of pistons is particularly mentioned, as the hot spot which may cause a disastrous crank-chamber explosion is often due to faulty piston assembly and maintenance. The top of a piston is difficult to cool, not being in direct metallic contact with the cooling-water system. Uncooled pistons are liable to crack due to excessive heat, and this is one of the dangers of overloading one cylinder of a multiple-cylinder engine. Often they can be repaired by welding, or by a false centre made from special heat-resisting material. It is unwise to let cracks develop until they go through the piston head, as a crankchamber explosion may occur. Other cracks which may result in a bad breakdown are those caused by surface heating due to seizure; they will show as small hair cracks on a smooth surface.

When cleaning-up a piston for re-use after a piston seizure, great care must be taken, because the piston may distort, and when it is replaced a secondary seizure is likely to occur, away from the seizure marks that have been removed. When the piston is replaced, the engine should be run for a short period on light load. The piston should be then again removed and have high bright spots honed down.

SOME CAUSES OF PISTON SEIZURE

Blow-by will cause heating of the piston, destruction of the lubricating-oil film, and expansion of the piston skirt, which normally has

* Paper presented to the Diesel Engine Users' Association in London on March 18, 1954. Abridged.

a small clearance, the result being a seizure and possibility of a crankchamber explosion. Blow-by often occurs after an overhaul, especially if the liners have worn oval. If rings are not replaced in the same position as before, blow-by will occur on starting up until, as it is often said, "they settle down," which means they wear or move to form a gas seal. It is unwise to continue running the engine if blow-by is increasing, as the heat disrupts the lubricating-oil film. If an engine is stopped and allowed to cool, the resultant renewal of the oil film may prevent the recurrence of blow-by on starting up. It is the usual practice to arrange rings so that the joints are 120 or 180 deg. apart; but rings should be replaced in the same position as before, unless any joints are sufficiently near to cause blow-by.

With the fixed type of gudgeon pin great care has to be taken to ensure that the piston is not distorted when the pin is driven in. When a piston is hot, it becomes oval and the pin is liable to keep it in this position; tapping the pin on the opposite end will often relieve this strain. Many seizures have occurred due to this distortion; also a hot gudgeon bearing has caused local expansion and seizure. For this reason, extra clearance on the piston should be given round the gudgeon-pin boss.

Cases have occurred where pistons have cracked through gudgeon-pin bosses when floating-type bearings are used with hollow pins. Due to the section of the pin not being strong enough to resist radial flexure, the pin cracked the cast-iron piston boss which restrained this flexure. When bearing clearance becomes excessive, the hammer blow on reversal increases this tendency, and this has caused cracked pistons after many hours' service. If piston rings become solid in a piston after long periods of light-load running, subsequent full-load conditions will cause seizure on the piston-ring surfaces as a result of expansion, and parting of the piston due to a crack in a ring groove. Piston heads have cracked at the bottom of the uppermost ring groove, due to expansion of the piston head and to the reduced thickness of the piston at this point. The predominant cause of such fractures has been a sharp corner at the bottom of the ring groove.

CYLINDER COVERS

Fractured cylinder covers still occur after a long period of use, but by improved design and better maintenance this trouble has been greatly reduced. It will always be a problem to obtain good circulation of cooling water in cylinder covers because, for efficient combustion, the valves must be as large as possible, compatible with sufficient water space.

The main causes of cylinder-cover fracture, apart from scale formation, are the unequal expansion between the cover and the uncooled exhaust-valve cage (when fitted), and differences in temperature between induction and exhaust-valve ports. To accommodate the air-induction and exhaust ports, the depth of the covers is generally about a third of the cylinder diameter, resulting in unduly long cages, particularly when the exhaust-valve cage is not cooled. With an exhaust temperature of 650 deg. F. and over, the cage expands more than the cover. If it is rigidly held in position, expansion will crack the cylinder cover or valve cage and has been known to fracture or pull out studs. In many engines this expansion has been compensated for by less rigid design. On some engines, it has been found advisable to have a flexible copper joint between the valve cages and the cylinder cover. It is most inadvisable to "harden down" the valve cage nuts to stop small leaks. If a bad exhaust leak occurs, some action must be taken or hot gases will burn the valve seating.

In some old-type cylinder covers, the water passages are so restricted that, with an outlet water temperature of 130 deg. F., boiling of the circulating water can occur at hot spots, causing scale deposit, which is one of the main causes of the cracking of cylinder covers. Water circulation can sometimes be improved by fitting an internal pipe, taking water to a hot spot.

Scale formation occurs at points that are not visible when inspection doors are removed. The removal of scale by use of an inhibited acid is to be recommended. On using this acid, the presence of unseen scale is proved by froth in the liquid, due to gas formation. Another cause of cover fracture and distortion is overheating, if no after-cooling is arranged for when the engine is stopped; also, the after-cooling may be too rapid. On shutting down, the flow of cooling water should be adjusted so as to keep the outlet temperature steady for a period, depending on the size of the engine.

FUEL-OIL SUPPLY SYSTEM

To obtain correct burning of the right quantity of fuel in a fraction of a second is the main essential problem. Absolute cleanliness of the whole fuel supply down to the nozzle point must be the main objective of those in charge of maintenance. Any small pieces of abrasive matter will have a ruinous effect on fuel pumps, valves and injectors. The condition of the very small holes in nozzles can only be appreciated by the use of a microscope. A test pump is normally used to check the type of spray and the prevention of any "after drip" while adjusting the release pressure. Often extreme care is taken when reconditioning, but the system is then tested with dirty fuel in the test pumps and with connecting pipes having open ends not protected from dirt.

Some trouble has been experienced with fine copper gauze filters; small holes are made by accident and the filters become useless. If the fuel oil is slightly acid, it may cause sudden collapse of the filters, due to slow and unsuspected deterioration of the gauze. For filters it is advisable to use a special gauze unaffected by acid, or to use fabric filters. To allow of satisfactory cleaning, the dual type of filter should be used. It is always advisable to have a new set of nozzles in stock. To refit worn nozzles, skill and special tools are required; this particularly applies to the fuel-injection pump. Even if a nozzle leaks only slightly on test, under running conditions that wet nozzle will cause carbon cones, bad combustion, dirty exhaust and stuck rings.

Bad carbon-cone formation can be assumed if the colour of the exhaust changes periodically at constant load. The formation of cones causes bad atomisation, but when they have grown large, they break off and for a time fuel is again properly injected. Normal dismantling may not disclose these cones—they drop off unless great care is taken in removing the nozzle.

Fuel-storage tanks should be placed slightly out of the horizontal to collect water and sediment, which can be drawn off by a drain cock. The fuel is pumped up into the engine room tanks, and, although the engine house delivery connection is generally a foot from the tank bottom, trouble has been experienced due to water and sediment getting into service tanks. Clean fuel oil can be assured by settlement.

FUEL-INJECTION SYSTEM

If the power developed by each cylinder is not the same, one cylinder may become overloaded, even if the plant is not running at full load. Due to wear of cams, chains or gears, the time of injection can be retarded and the condition of spray and quantity of fuel can also be affected. The running conditions deteriorate slowly due to the effect of wear. For this reason, after some years, it is wise to repeat the acceptance trials and to compare the results obtained.

If the manufacturer's instruction books are carefully studied and their recommendations faithfully observed, defects in fuel injection can be detected and put right but in some cases the books of instruction are never seen by those who repair the engine.

The usual method of comparing work done by each cylinder is by observation of the exhaust temperatures, but this does not always indicate the amount of work done. A leaky exhaust valve will increase the exhaust temperature, or it might be due to bad combustion, retarded injection, defective spray, or restricted air supply due to a choked air filter. It is difficult to detect the cause of high exhaust temperature without the use of indicators, but if the engine is well maintained most troubles will not occur. It is generally assumed that, if the exhaust is clear, combustion is satisfactory, and if it is smoky, combustion is bad. With one outlet, it is impossible to know which cylinders are not working properly. A simple method of checking the exhaust of each cylinder is to fit a test cock on each branch of the exhaust pipe.

LUBRICATING-OIL SYSTEM

A clean supply of cool lubricating oil to all parts of an engine is a vital necessity. Deterioration of plant is due to wear, and if moving metal parts could be kept apart by a film of lubricant no wear would occur.

In most engines the lubricating oil passes through the pump into a main pipe line, from which branch pipes supply oil to the various bearings. Due to the number of take-offs, the pressure will drop towards the end of the system remote from the pump unless the main pipe is of ample size. Two pressure gauges should be fitted, one immediately after the pump and one at the remote end of the main pipe. In most cases, there is a slight pressure drop at the end of the system, which should be recorded at the original trials. If the normal drop in pressure increases, it is an indication that there is leakage at some point caused by increased bearing clearance or a failure of the pipe system.

It would be an advantage if more attention were paid to cooling the lubricating oil; the average modern engine would work better with lower lubricating-oil temperatures. Lubricating oil coolers are often too small and soon become inefficient. For the oil coolers, it is usual to use engine circulating water, which is of necessity at a high temperature, whereas a separate cold supply would be an advantage; one manufacturer cools the engine bed with great success. On a number of engines, the oil cooler has been supplemented by passing the engine circulating water through a coil in the lubricating-oil tank.

Hot oil is often subjected to extra heat to get it through the oil filters. The normal heating of oil is increased in the big-end bearings, due to heat passing down the connecting rod. The big-end bearing can become sufficiently hot to damage the white-metal lining, causing surface cracks and scuffing. Lead-bronze bearings will stand up to severe punishment, but if they seize the crankshaft journals may be damaged beyond repair.

To keep bearings cool the lubricating oil must be used also as a coolant. The usual remedy for hot bearings is to increase the running clearance; more oil gets through the bearing but at the same time it causes knock, which hammers the white-metal and makes it crystalline.

The precaution must be taken of giving an extra clearance at the point of low working pressure, i.e., at the horns of bearings. An extra clearance at this point allows the lubricating oil to flow through the bearing and act as a coolant without affecting working clearance.

LUBRICATING BEFORE STARTING

A hand pump is generally used to charge the system. Often the pressure gauge cannot be seen when working this hand pump; under these conditions, the attendant cannot be expected to do this important job properly. Difficulty may be experienced in getting oil up to the gudgeon-pin bearing. When at rest, oil drains from the hole in the connecting rod or external pipe connection, leaving a column of air sealed off by the gudgeon-pin bearing. During each stroke of the hand pump, air is compressed unless a groove is made in the bearing, leading away from the oil hole, to act as an air escape vent. Incidentally, the vent increases the oil flow and assists in cooling this hot spot.

Proper lubrication of all parts is assisted by turning the engine; this applies especially to the cylinder liners, which may be dry after a long stop. If cylinder lubricators are not fitted, the only lubrication obtained is from the piston on turning the engine; a certain amount of oil is trapped between the piston rings. On some

pistons, oil-retaining grooves are turned or cut by hand. If piston seizure occurs near these grooves, it is a wise precaution to inspect the grooves as, if they have sharp corners – which is not unusual – cracks may result from rapid local expansion.

AIR-SUCTION SYSTEM

It is most important that the air suction should not be restricted in any way, so decreasing the amount of oxygen available for combustion. The necessity for an air filter depends on the amount of abrasive in the air supply. Any filter fitted should be of ample capacity to allow free passage of air. Where convenient, large air filters can be placed outside the engine house; this enables windows and doors to be closed, and prevents noise being heard outside the engine house and decreases noise within.

However much care is taken, a certain amount of blow-by will occur, and unless the crankchamber is properly vented the atmosphere becomes unpleasant and a film of oil will be deposited on electrical gear, etc. It is for this reason that the crankchamber vent is generally directed into the air suction system, and on large engines an extractor fan is sometimes fitted to the crankchamber. With such fittings, blow-by may become serious before being detected and, if the temperature of bearings is unfortunately high enough, evaporation of the lubricating oil takes place. The more air drawn through the crankchamber, the greater will be the lubricating-oil consumption.

CIRCULATING-WATER SYSTEM

The circulating system that appears to give the least trouble is the enclosed type, using pure unaerated water in the engine circulation, and cooling this medium with raw water in a heat exchanger. To prevent distortion of metal parts and retain the heat of combustion, the inlet and outlet temperatures should not differ more than 20 deg. F. Even when an enclosed system is employed, the circulating water may become contaminated through leakage of tubes in the heat exchanger.

With the open tank or cooling-tower system cooled by evaporation, a serious concentration of hardness can occur if hard water is used to replace pure water lost by evaporation. In such cases, bad scaling of the engine will be experienced. The only remedy is to treat the water with some chemical or to drain the whole system frequently.

In the early days, cylinder covers frequently cracked. When a complaint was made to Dr. Diesel he replied, " A cracked plate does not break, neither do cracked cylinder covers, because the internal stress has been relieved." This has proved very true, but unfortunately sometimes the crack goes into the water jacket which will leak into the cylinder and cause serious trouble if the engine is started without being barred round. It is a wise precaution to have a periodic test made of the hardness of the circulating water in the system, unless the water used is known to be soft. If scale does form in circulating-water passages, it must be removed.

In many cases, scale formation in cylinder covers is not suspected because it forms in the inaccessible hot centre of the cylinder cover, where the circulation of water is insufficient unless special precautions are taken to fit an internal pipe or other method of directing the cooling water to the centre of the cover. These internal fittings have been know to corrode.

Where a number of engines are supplied with water from a common main, trouble has been experienced in maintaining a constant adequate supply, the main not being of sufficient diameter. Many seizures have occurred due to sudden changes in water temperature. It is bad practice to cool down an engine rapidly after shutting down; this can cause cracking of covers. Sometimes it has been found that, if cold water is allowed to pass through the system for a very short period after stopping an engine, the clearance between a hot piston and the liner is reduced sufficiently to make it difficult to turn the engine. Starting under these conditions might be dangerous, so it is always best to turn an engine before starting.

Cylinder liners are at times difficult to remove because of corrosion and scale formation between the skirt of the liner and the jacket, due to the first rubber ring being below the machined metal surfaces; if this ring is placed high up, to protect these surfaces from coming into contact with water, the liner remains free at this point. Seizures have occurred due to the inward thrust on the liner at this position, which may be caused by foreign matter packing up at this breathing joint.

Distortion of liners can be caused by the use of oversize rubber rings. A water pressure test should be applied when new liners are fitted. The top of the liner is subjected to the maximum heat of combustion. When the liner is a tight fit at the top diameter, it has been known to crack the jacket when hot.

STARTING THE ENGINE

The starting lever should be in the stop position, with the compression-relief cock open, and the engine should be turned while operating the lubricating-oil pump. With one operator, the auxiliary lubricating-oil pump should be operated till the pressure gauge shows a steady running pressure; the engine can then be turned to lubricate all parts. It is advisable to turn engines while pumping, as this ensures a good supply of lubricating oil to the gudgeon-pin bearings. When training a driver, it is a wise precaution to make him continue pumping till oil seeps down the connecting rod. He then realises the time taken to get oil to the gudgeon pin. If the engine is started before the system is charged, air locks may prevent proper lubrication on starting. After putting the flywheel on starting centre and closing the compression-relief cocks, the water circulating valve is opened to charge the system and ensure an equal flow from all cylinders, if the outlets can be seen.

The fuel supply can now be opened and the fuel-injection pumps hand-operated till each atomiser pipe system is solid with fuel. It may be necessary to turn the engine and open the vents if the engine has been standing for some time. It is bad practice to go on pumping till fuel enters the cylinders. The air starting valve is then opened and the fuel supply hand-controlled while the engine slowly picks up speed. The natural tendency to give the engine plenty of fuel, to make sure that it will start and quickly attain full speed, should be guarded against. Under these conditions, heavy firing knocks are often heard. During this period, cylinder pressures of over 1,000 lb. per square inch have been recorded. Cracked bearings are often caused in this way. Where outboard pedestal bearings, camshaft bearings, etc., are ring-lubricated, there is a chance that the rings may not rotate when cold unless they are first moved by hand. When engines have been standing for long periods, they should be turned at least four revolutions with the compression-relief cocks open.

WORKING LIFE

Air-injection engines of the slow-speed type, fitted with heavy flywheels, have an almost indefinite life and they will only be discarded when spare parts cannot be obtained at a reasonable price, or when modern high-speed engines, developing three or four times the power, can be erected in the original power house if more power is required. Engines running at high speeds and high exhaust temperature will need more repairs, but the life of any engine can be prolonged by good maintenance and regular replacement of worn parts. Generally, the wear of parts occurs approximately in the following order: exhaust valves, piston rings, connecting-rod bearings, main and all bearings, cylinder liners, atomisers, induction valves, fuel-injection pumps, governor-link motion and bearings, all springs, cams and valve-gear.

Because of the cost of spares, it often pays to have valves reconditioned and to fit false seats to valve boxes. If precautions were taken to treat piston rings as delicate valves, breakages of rings should decrease, but with the top ring high on the piston, heat does burn the lubricating oil and stick the ring.

Thin-walled connecting-rod bearings must be renewed when wear occurs, because of the thinness of the white-metal lining. If thick-walled bearings, having a reasonable thickness of white metal, are used, they can be made to last for many thousands of hours if a proper clearance is maintained by use of shims to adjust it. A rigid bearing cannot be ensured if a large number of shims are used. Fearing trouble caused by misuse of thin shims, some manufacturers leave the shims out or supply a thick distance piece which has to be decreased in thickness to take up the clearance. It would appear almost impossible to do this work by hand. The suggested shims can be fitted to the thick plate if it is planed down.

When to replace liners because of wear is a question to which no definite answer can be given, as so many factors have to be considered and users' opinions vary; the average figure for the maximum permissible wear seems to be 0·004 in. per inch of diameter with liners over 10 in. in diameter. Pistons have a long life and generally have only to be renewed when the increase in width of the top piston-ring grooves causes excessive reduction in land width. Cracks which may occur in the piston head can nearly always be repaired.

The original small lift on atomiser valves increases from wear on the tappet and valve faces, and the nozzle holes increase in diameter and may be damaged, or the valve sticks. It is advisable to renew this important part under these conditions and to have the old valves reconditioned by the makers. Induction valves rarely give trouble, although the tappet and the spring may need renewal after long periods in use.

If there is leakage past the plungers of fuel-injection pumps, or other signs of wear appear, they should only be repaired by the manufacturers or by specialists in this type of work; they are not often repaired satisfactorily on site. Breakdown of the hardened surfaces of the operating cam and roller has occurred and cam faces may wear. The slightest wear on these parts prevents proper injection of fuel. Movement of adjustable toe pieces can cause retarded injection.

GOVERNORS

After may hours' running, governors tend to hunt from lost motion due to wear, which causes an increase in the rate of wear and sometimes fracture of the spring attachment. Unsuspected excessive wear may occur on the fulcrum pins of weights, because they are constantly bearing on the same spot and the revolving mass is difficult to lubricate. Unless the tension is taken off the springs, this wear cannot be detected. Where ball-bearings are fitted, the balls tend to bed into the race at the normal working position. Governors have failed to operate when the load is suddenly removed, due to some cause of this description.

The tachometer mechanism is vibrating in the same position for thousands of hours; this also applies to the gauges. It is remarkable that more wear does not occur, and that they continue to record accurately. It is advisable to have these instruments tested or interchanged if the readings recorded do not appear to be correct.

Flywheels have burst due to neglectful maintenance, and lack of instruction of the staff. Under such conditions information as to the cause of accidents is difficult to obtain at the time of the occurrence. It is advisable not to ask questions at the first visit, when neglect is suspected. It is easier to obtain the truth after the repairs are paid for, and there is no chance of anybody getting into serious trouble. Making a friend of a good man who has unfortunately made a mistake is better than getting him discharged. By such means it is possible to secure the goodwill and future co-operation of those in charge, and also to obtain valuable information which helps to avoid similar troubles.

KEMANO-KITIMAT HYDRO-ELECTRIC SCHEME

TRANSMISSION OF 1,670,000 H.P. AT 300 KV FOR ALUMINIUM-REDUCTION PLANT

The Kemano-Kitimat hydro-electric scheme,* which is being carried out by the Aluminum Company of Canada, will make use of the water resources of the Coast Range country of British Columbia, about 500 miles from Vancouver and 180 miles from Prince Rupert. The civil engineering works include the construction of a 1,550 ft. long rock-filled dam 317 ft. high across the Nechako River, into which 12 lakes flow, thus forming a reservoir with a capacity of 873,000 million cub. ft. As a result the water flow has been reversed through the Tahtsa River and Lake where a second dam has been constructed. A third dam is being built at Skins Lake to divert any rise above the 2,800-ft. level in the reservoir into the river about five miles below the main dam. The Nanika-Kidprice lakes will also be dammed and their water diverted into Lake Tahtsa through a tunnel. Finally, eight smaller dams are being constructed in the watershed to prevent the escape of water as it reaches the higher run-off points.

The water thus impounded will be carried through a ten-mile tunnel under the Du Bose mountain, at a point 140 miles west of the main, or Kenney, dam to a power station at Kemano. This power station, which is constructed underground, will eventually contain sixteen 140,000-h.p. generators, three of which are at present installed. The final capacity will be 2,240,000 h.p. The first phase of the work covers the three sets already installed; the second phase will cover five more sets; and the third and final phase will add a further eight sets. From Kemano power will be transmitted at 300 kV a distance of 48 miles through difficult mountainous country to Kitimat, where an aluminium smelting plant with an initial output of 83,000 metric tons of aluminium per annum is being built.

HYDROLOGICAL CONDITIONS

The valleys of the western slopes of the Canadian Coast Range reach sea level close to the coast and thus constitute large fiords. The eastern slopes are occupied by long, narrow and deep lakes with their extremities close to the crest. It is this unusual topographical development which has created the necessary water power that is being developed in the Kemano-Kitimat scheme.

The total watershed which is being utilised extends over some 5,765 square miles in which the precipitation varies from 100 in. per annum in the western to 20 in. per annum in the easterly portion. By damming the Nechako River, near the head of the Grand Canyon, some 16 miles downstream from Lake Natalkuz, a reservoir with a capacity of 873,000 million cub. ft. and an average total run off of 7,470 cub. ft. per second is being formed. This reservoir will also impound the water of Lakes Eutsuk, Tetachuk, Euchu, Whitesail and Natalkuz and will reverse the flow of the River Nechako into Lake Tahtsa and thence through tunnels under the mountains to the power station at Kemano. Other storage, diversion and control dams will impound the tributaries of the River Nechako, the ultimate result being that the level of the reservoir will be 15 ft. higher than the original level of Lake Tahtsa. The positions of the various works are shown on the accompanying map.

At the site in the Grand Canyon where the main, or Kenney, dam has been constructed, the exposed rock consists of volcanic flows and tuffs of tertiary age, the strata being nearly horizontal but dipping slightly downstream. At the axis of the dam the upper surface of a formation of relatively weak tuffs and ash rocks lies 170 ft. below the river. Above this is a coarse volcanic breccia about 150 ft. thick, which is overlaid by a series of vessicular volcanic flows about 200 ft. thick. On these, more massive and non-vessicular volcanic flows, extending far above the crest of the dam, are superimposed. Running parallel to the volcanic ridge and directly across the river a short distance above the site of the dam is a dyke of felspar porphyry several hundred feet wide and extending to great depth. This acted as an effective cut-off in the underlying relatively weak rocks.

KENNEY DAM

The Kenney dam, which is about 1,550 ft. long and 40 ft. wide at the crest, is of the Nantahala rock-fill type and is 317 ft. high above bed rock. The slope of the upstream face is 1 in 2·5 and of the downstream face an average of 1 in 1·75, this average being obtained by a series of repose slopes and berms. The foundation is trimmed so that slopes of 1 to 1·5 will not be exceeded near the impervious core, thus eliminating the possibility of tension cracks in the latter due to differential settlement. The longitudinal axis has a slight camber upstream, thus putting the core under axial compression and decreasing the possibility of tension stresses in it.

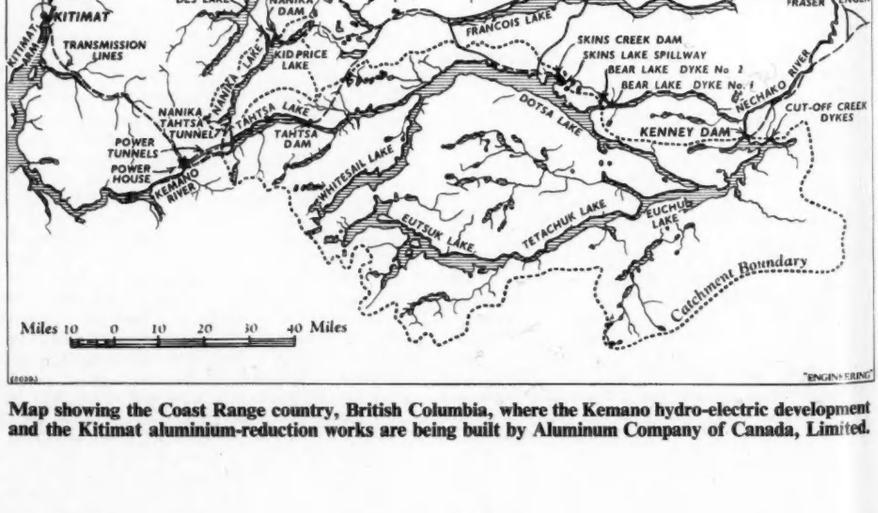
The impervious core extends from a cut-off trench in sound rock to near the top of the dam. It is prevented from being forced into the rock fill on the downstream side and into the blanket on the upstream side by filters of sand and crushed rock or gravel. Below the core the upper 25 ft. of rock was grouted at a pressure of about 30 lb. per square inch and deep holes were then drilled through the resulting consolidated upper zone and higher pressures used.

Another similar dam, 800 ft. long and 105 ft. high, has been built about ½ mile below the outlet of Kidprice Lake to store and divert the water of that lake and of Lake Nanika. To handle the flood water of the reservoir thus formed, a free-crest spillway has been constructed across the western end of Des Lake, while later it is proposed to drive a free discharge tunnel 3·8 miles long up hill from the Tahtsa portal to divert water from the Nanika-Kidprice watershed.

POWER TUNNEL

The western end of Lake Tahtsa, a distance of 140 miles from Kenney dam, is connected by a short channel 80 ft. wide to a concrete structure equipped with trash racks, bulkhead guides and two 14 ft. by 26 ft. fixed wheel gates. At this point the water will enter two tunnels which will be for the most part, unlined, although the inverts will be paved with concrete. Their equivalent diameter is 25 ft., their length to the base of the surge chamber above Kemano is 10·1 miles. Each tunnel will normally carry 3,500 cub. ft. of water per second, although designed for a maximum of about 4,500 cub. ft. per second.

Only one of these tunnels is, however, at present being driven, for which purpose excavation has been conducted from four headings, one at each end and two from a 1,600-ft. adit near the midpoint of its length. The altitude of the gate sill of the tunnel is 2,725 ft., and that of the invert at the surge chamber about 2,591 ft. above sea level. The outlet from the surge chamber consists of a steel Y-piece which is connected to two 11-ft. diameter pipes. Each of these pipes is controlled by a butterfly valve which is installed 300 ft. lower down and is operated by oil pressure. Just downstream of these valves is an inlet valve, so that air can be admitted into the pipe when it is drained for inspection or maintenance. The pipes are about 4,000 ft. long and at their lower ends are connected to a manifold which tapers to four 5-ft. diameter



Map showing the Coast Range country, British Columbia, where the Kemano hydro-electric development and the Kitimat aluminium-reduction works are being built by Aluminum Company of Canada, Limited.

* This description is based on an article by Mr. F. L. Lawton and Mr. J. S. Kendrick, which appeared in *The Engineering Journal*, Vol. 35, page 915 (1952) and on a paper read by Mr. F. L. Lawton before the Institution of Electrical Engineers on Thursday, March 25, 1954. Mr. Lawton is chief engineer, Power Department, Aluminium Laboratories, Limited, and Mr. J. S. Kendrick, assistant manager, Aluminum Company of Canada, Limited.

branch pipes each of which serves one 140,000-h.p. generating unit. The maximum velocity in the 5-ft. pipes is about 23·6 ft. per second and the flow in them is controlled by double-seated spherical valves with cast-steel bodies.

UNDERGROUND POWER STATION

The 16 140,000-h.p. generating units which will eventually be installed in the Kemano station will be housed in a chamber excavated from the solid rock. This chamber will be 1,135 ft. long by 81 ft. wide by 134 ft. high, and is located about 1,400 ft. from the face of the mountain. A regulated flow of 6,920 cub. ft. per second under a net head of about 2,500 ft. will allow the generation of a total of 1,718,000 h.p., although it will be possible to obtain 2,240,000 h.p. over considerable periods. The largest four-nozzle vertical single runner impulse turbines which it is possible to build for this head have a rating of 140,000 h.p., a figure which complies with the possibilities of generator design and transport limitations.

The governors of these machines, of which three are at present installed, are actuated from permanent-magnet generators. Each turbine is protected against overspeed and loss of governor oil pressure and is equipped with bearing-temperature, oil-flow and water-flow alarms.

Pressure surges necessitate the minimum turbine-nozzle needle opening time being about 30 seconds. Initially, operating requirements involve picking up two 100-MW blocks of load, one at a time, and carrying this load on at least two generators. This requirement has been met by providing a pre-set needle opening, which is operated by a solenoid, the latter being excited by pressing a button in the control room. As the needles open and the frequency rises, the governor inserts deflectors in the jets, thus reducing the water input to the turbine and stopping the frequency rise. When the needles have opened to their pre-set position at about 75 per cent. of full load, as indicated by a lamp, the operator at Kitimat is instructed to pick up the load in the aluminium reduction plant. The resulting drop in frequency causes the deflectors to be withdrawn and the unit to generate the output demanded. The operation of the deflectors has no effect on the water flow through the conduit system and only takes about three seconds. A loss of load does not cause excessive frequencies, as the deflectors rapidly direct the jets away from the turbine buckets. As a result it takes the needles the relatively long time of about one minute to close, as required by the hydraulic conditions in the tunnel and conduit system.

ALTERNATOR DESIGN

The vertical-shaft alternators, which have a rated output of 106 MVA at 60 deg. C. temperature rise, or 122 MVA at 80 deg. C. temperature rise, have 22 poles and generate three-phase current at 13·8 kV and 60 cycles, with a power factor of 0·8. At these ratings their speed is 327 r.p.m., but they are designed for 610 r.p.m. overspeed. Excitation is by direct-connected main and pilot exciters with voltage regulators actuating motor-operated rheostats in the main exciter circuit. The thrust and upper guide bearings are located above the rotor with a second guide bearing below it. The stator winding is suitable for split-phase protection and the ratio between the field-discharge resistance and the field resistance is at least 8 to 1. The alternators are furnished with the usual temperature detectors and flow alarms in the water and oil circuits and may be operated with the stator neutral either solidly earthed or earthed through a loaded distribution transformer.

Each alternator is coupled to a bank of three single-phase forced-oil water-cooled transformers with a nominal rating of 213 MVA through two air-blast circuit-breakers with a rupturing capacity of 1,500 MVA, which are operated as a single unit, the connections consisting of 7-in. double aluminium channel. These transformers, which have double primaries, are connected delta-delta-star and step the voltage up to 301·4 kV. Each primary winding can carry its full rated load independently of the other. The choice of single-phase units was dictated by transport conditions and the use of double primaries by the necessity of limiting the length of the underground power-house in which they are installed.

SWITCHGEAR LAYOUT

The high voltage sides of the step-up transformers are connected to a switching station above ground by three paper-insulated oil-filled cables of the Pirelli type, the minimum current carrying capacity of which is 550 amperes. The length of these cables is about 2,000 ft. and they rise through a height of 75 ft. Initially, the conductors forming one of these circuits are of aluminium with an outside diameter of 1·09 in., and of the other, copper with an outside conductor diameter of 1·17 in. In the first case the sheath is also of aluminium and in the second of lead. The cables are installed in a special tunnel, which is divided into two sections by a vertical wall. Two circuits carrying the output of four generating units are installed in each section on insulated supports there being a vertical distance of 5 ft. between the circuits and a horizontal spacing of 1 ft. between the cables forming the same circuit. The sheaths are earthed at the midpoint only to eliminate losses in them.

The 301-kV circuit breakers are of the air-blast type and have a rupturing capacity of 6,000 MVA, the rate of rise of their recovery voltage being 1,850 volts per microsecond. The opening time is five cycles and the closing time six cycles, both opening and closing imposing a drain of 3 amperes on the storage battery. The line isolators are rated at 1,600 amperes and are equipped with interrupters in parallel with the main blade to give a rupturing capacity of 90 amperes when breaking a line-charging current at 300 kV or a load current of 800 amperes with 60 kV across the isolator. These operations can be effected several times before serious contact-erosion develops. It is expected it will be possible to switch in the transmission lines without using the circuit-breakers. Should this prove feasible and transmission line faults be as low as anticipated, circuit-breakers will not be installed on the outgoing lines although provision has been made for them.

In designing the control room the basic problem was to arrange the panels, relays and instruments for the 16 machines, so that the operator could see and reach all the necessary points. As laid out, the maximum distance between the operator's desk and any instrument is 21 ft. It is proposed to telemeter the voltage on the high voltage 'bus-bars at the Kitimat factory to the control room at Kemano, so that during the initial stages of development the operator can raise the voltage at the former place by an amount equal to the drop when the load is applied. During the later stages of development this will be unnecessary except perhaps in the unlikely event of a total interruption.

DESIGN OF TRANSMISSION SYSTEM

The first ten miles of the transmission system between Kemano power station and the aluminium reduction works at Kitimat consist of two double-circuit lines. These rise to a height of about 1,000 ft., at which point they feed into a switching station which is equipped with motor-operated selector/isolator switches. From this point two single-circuit lines traverse a pass at a maximum altitude of about 5,300 ft. for a distance of 10·6 miles and then descend to a second switching station at Kildala, the altitude of which is 500 ft. From Kildala two other double circuit lines run to Kitimat in the course of which they rise to between 2,000 and 3,000 ft. for about three miles.

To design a transmission system to carry 1,670,000 h.p. "firm delivery" through narrow valleys, where snow and rock slides may occur, as well as across a narrow pass with a maximum altitude of some 5,300 ft. was a difficult problem. The snow may lie 20 ft. or more deep, and icing conditions may be very severe. Moreover, the lines must be absolutely reliable, since the aluminium reduction process is continuous. A test span of 795,000-circular-mil steel-cored aluminium cable was therefore erected at the summit of the Kildala Pass and equipped with recording instruments. During the winter of 1950-51 the maximum ice loading observed on this span was 2·4 lb. per foot, as against the 27 lb. per foot obtained at an altitude of 4,806 ft. in the Puy de Dôme.

STEEL-CORED ALUMINIUM CABLE

Standard steel-cored aluminium cable with an overall diameter of 1·545 in. and weighing 2·032 lb. per foot has been used for the double circuit lines, there being a double earth wire at the terminals consisting of a $\frac{3}{4}$ in. steel cable with an ultimate strength of 50,000 lb. The insulation consists of sixteen 10 in. by $5\frac{3}{4}$ in. 25,000 lb. suspension units in suspension strings and 18 in the strain strings. Single strings are used at suspension points and double strings on the long spans. At strain points triple strings are employed. The ice load at 24 lb. per foot of conductor length at 0 deg. F. has been taken as the yield point load. The stresses under normal working loads have been computed on the triple basis of a 2 in. radial deposit of ice on the conductor; a 2 in. radial rime deposit on the conductor, combined with wind at 8 lb. per sq. ft.; and a $\frac{3}{4}$ in. radial rime deposit, combined with wind at 11 lb. per sq. ft. and a broken conductor.

To allow for the weight and creep due to their being buried in snow, all the members of towers installed at heights above 3,200 ft. are considered to be subjected to a vertical load equal to $(3{,}000 - 100h)$ lb. per foot of horizontal projection of member lengths, where h is the height in feet above the ground line; and to a horizontal load of 300 lb. per ft. of member length acting in any direction. These loads are applied to all members below 19 ft. above the ground line. Members of towers located at heights, between 1,000 and 3,200 ft. are considered to be subjected to a vertical load equal to $(1{,}000 - 40h$ lb.) per foot and a horizontal load of 100 lb. per ft. these loads being considered applicable to all members below 13 ft. above the ground line. The loads in each case are independent of the cross-sections of the members and their effects are considered separately and independently of the effects of the conductor loads.

Various types of footings have been used; steel grillage on earth, gravel, broken or rotten rocks; rock anchor on sound, solid rock, and concrete pedestals in special conditions.

Steel-cored aluminium cable with an outside diameter of 2·295 in. and weighing 4·77 lb. per foot is being used for the single circuit through Kildala pass. The insulators are similar to those on the double circuit lines, except that there are 18 units in the suspension and 20 in the strain strings. Triple or quadruple strings are being used for suspension and sextuple strings for strain purposes. A maximum swing of 36 deg. from the vertical will be allowed. An ice load of

40 lb. per ft. of conductor length at 0 deg. F. has been taken as the yield-point load. The stresses under normal working loads have been computed on the triple basis of 2·5 in. radial deposit on the conductor; 2 in. radial rime deposit on the conductor, combined with a wind of 8 lb. per sq. ft. and ¾ in. radial rime deposit combined with broken conductor action. Under some conditions a wind load at 120 m.p.h. has been assumed to be acting on the tower surfaces.

One of the two single circuit lines across Kildala Pass is carried on steel towers of conventional design. The other line is supported on aluminium towers, consisting of a broad H-frame with five thin-walled tubes of about 38 in. in diameter and a box girder cross-arm. These towers weigh substantially less than the steel towers and are expected to be cheaper in transport, erection and maintenance.

A carrier system consisting initially of three duplex channels is to be installed for communication between Kemano and Kitimat. It will also provide a telemetring channel, as well as a remote tripping scheme actuated at Kitimat and phase-comparison relay protection, if these are required. The equipment, which has automatic gain control, will operate through 63 decibels or 80 decibels in the absence of noise. At Kitimat the incoming supply is stepped down in three banks of 275/13·2 kV single-phase forced-oil water-cooled transformers with four 2·5 per cent. tappings, the neutrals of which are solidly earthed. Control is effected by circuit-breakers and isolating switches similar to those at Kemano. The 13·2 kV 'bus-bars are connected through oil circuit-breakers with a rupturing capacity of 1,000 MVA to two groups of eight 12·5 MW mercury arc rectifiers of the ignitron type. Each of these equipments comprises a 13·2 MVA self-cooled phase-shifting transformer (of which two provide 15 deg. and four 7·5 deg. phase shift) and is arranged to give 48-phase operation; and a 13·2 MVA self-cooled rectifier transformer with a three-phase primary and two six-circuit star-connected secondary windings. These windings supply the 24 anodes of the rectifier frames, each of which consists of 12 pumped ignitron-type water-cooled units with its auxiliary equipment. The cathodes of the frames are connected through high-speed air circuit-breakers to 1,000-volt positive direct-current 'bus-bars. The neutral points of all the secondary windings are connected to the negative direct-current 'bus-bar through interphase transformers.

MECHANICAL TRANSMISSIONS FOR HELICOPTERS

GEAR DESIGN AND LUBRICATION; SHAFT COUPLINGS

This article describes some of the problems encountered in developing high-duty mechanical drive systems for helicopter rotors. It is abstracted from a paper entitled "The Design of the Drive," given before the Helicopter Association of Great Britain on Friday, March 5, by Mr. J. L. Norton, A.M.I.Mech.E., of the Bristol Aeroplane Company, Limited.

GEAR EFFICIENCY AND STRENGTH

The discrepancy between engine r.p.m. and rotor r.p.m. compels the designer to use some form of speed reduction, usually effected by gears. Neglecting bearing losses, each stage in a gear train represents a drop in efficiency of the order of 1 per cent., and correspondingly increased fuel consumption, increased cooling problems and increased weight.

A possible gear drive for a large helicopter rotor includes three stages of reduction, the greatest ratio being 4·7 : 1. An alternative layout comprises two stages with ratios of 8·2 : 1 and 6·2 : 1. With bevel gears, a major adverse factor is distortion of the wheel under load. In the case of the wheel for a large ratio, it is virtually impossible to provide adequate stiffness without exceeding acceptable weight limits. This can be overcome by using a small thrust pad (Fig. 1) to take the gear-tooth separating load, thus alleviating the duty of the wheel web. In addition, it also localises the stresses in the supporting structure, thus improving tooth-meshing conditions.

Design stresses can be exceeded by tooth distortion under load, by wheel-rim deflection and by manufacturing errors. The normal procedure is to apply suitable correction to tooth profile in the manufacturing stages, usually when finish-grinding the teeth, in the form of tip and/or root relief. The answer to the problem of wheel-rim deflection appears to be simply a matter of adding material to the rim. In some cases the design of a pair of gears can be such that an essentially stiff portion of the driving wheel would mate with the less stiff portion of the driven wheel, as shown in Fig. 2. In this way some load spreading can be obtained. Allied with wheel-rim stiffness is the problem of wheel-web strength. Holes are often drilled in the web in the interest of weight saving. This must be done with extreme caution, if fatigue failures of the type shown in Figs. 3 and 4 are to be avoided.

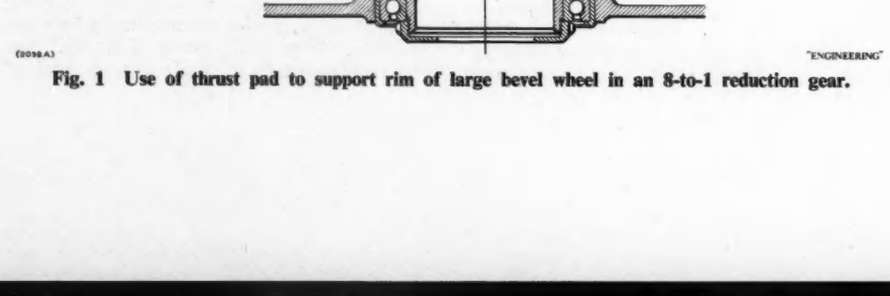


Fig. 1 Use of thrust pad to support rim of large bevel wheel in an 8-to-1 reduction gear.

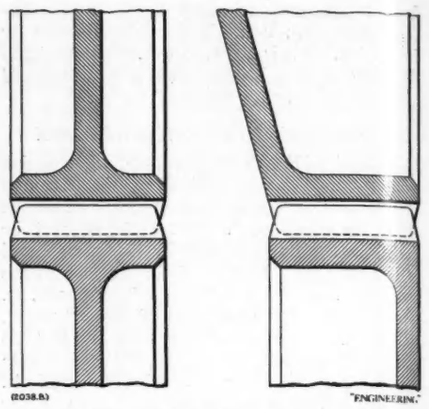


Fig. 2 The mating gears on the right are arranged with their webs displaced so as to reduce wheel rim deflection. The conventional arrangement is shown on the left.

There is a component of load trying to separate the gears, and if the shaft, bearings and supporting structure are insufficiently stiff, the teeth will be forced out of mesh to the point where both bending load and surface stress exceed the design figures. Lack of symmetry in the casing layout will aggravate this trouble, since not only will the pitch surfaces be separated, but one will be skewed relative to the other, thus accentuating the tooth load toward one end of the tooth. Such flexibility will also permit rapid displacements at tooth frequency with corresponding diversion of energy.

The nearer together the bearings, the stiffer the structure, and if the material of the casing is in compression so much the better. In this respect internal gears show advantages.

OIL-JET COOLING OF GEAR TEETH

Oil is circulated round the gearbox to cool the gear teeth, to lubricate the gears and bearings, and to cool the bearings. If the cooling of the teeth is properly done then gear lubrication looks after itself.

It is essential to use oil sparingly and effectively. As mating gears rotate, a pair of teeth come into contact and move on. Each tooth takes away, on and near its surface, a charge of heat. The best way to dispose of that heat charge is to wash it away by a jet of oil as soon as possible after the tooth emerges from the mating tooth space, and before it can soak into the body of the gear. Since the receding tooth leaves a depression or partial vacuum in the space between the mating teeth, the resulting in-rush of air helps the oil to the areas not directly sprayed by the jets. Nevertheless, oil jets of high velocity are usually necessary, located as close as possible to the disengaging teeth.

Thorough scavenging of the oil from the casing is necessary. With good general design, quantities of uncontrolled oil inside the gear casing do nothing to assist in lubrication, and result in a temperature rise due to "churning" or even to troubles of a more serious nature.

In cooling the main pairs of gears in the Brabazon reduction gear, a scoop collects oil

Fig. 3.

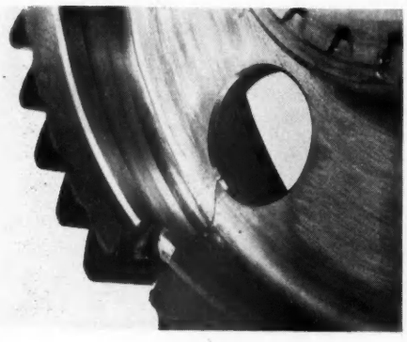


Fig. 4.

Figs. 3 and 4 Fatigue failure of large planet gear originating from lightening hole.

thrown back from the gear teeth. This then passes, via suitable drillings, to the pinion-shaft bearings. Thus the maximum temperature differential obtains between cooling oil and surface to be cooled and the quantity or rate of oil circulation can be reduced to a minimum. The higher oil temperature also promotes more thorough scrubbing of the walls of the casing, again helping the transfer of heat towards the atmosphere.

The gear tooth is now cool and it bears a film of oil on its surface. If, then, the tooth speed is not too high and, assuming the use of the right oil, that film will provide adequate lubrication when next the tooth meets a mate.

Oil injected between the teeth on the engaging side can cause considerable trouble. Pumping action between the teeth expels whatever is there, presumably air, and this air stream opposes the entry of oil. The natural remedial action is to move the jets in closer and to increase the oil pressure. The effect of these changes is that each engagement is forced to swallow a " gulp " of cool oil, and it promptly tries to compress it. At the speeds normally employed in aero-engine design, incredibly high oil pressures can be developed, with the result that (1) efficiency is depressed and therefore temperature rises, (2) tooth pressures and bearing loads and, therefore, deflections are increased, (3) torsional and linear vibrations at tooth frequencies are introduced, or considerably increased in amplitude.

HELICAL GEARS

Forced vibrations at comparatively high frequency, often traceable to imperfect gear-tooth meshing, can be experienced in a gear-driven system. With turbine engines, frequencies in the higher audio region can be produced and considerable quantities of energy must often be dissipated. Helical teeth offer promise of a cure, by virtue of tooth overlap. For difficult aero-engine engineering jobs the single-helical gear can show to better advantage than the double helical. In the single-helical gear, the axial component of load compels the use of a thrust bearing, but the end load need not be great. In addition to a steady axial component due to the mean torque, there is a superimposed fluctuating load due to resolution of the torsional vibration forces. Inherent elasticity, however small, permits the casings and supports to respond to these forces. Since the two mating gears react in opposite directions some rubbing occurs between the teeth, with consequent damping of these high-frequency vibrations.

FLEXIBLE-SHAFT COUPLINGS

It can be dangerous to permit induced torsional vibration in that part of the transmission shaft between two torsionally-flexible couplings. Conditions can arise in which a torsional excitation, applied through either the driving or the driven coupling, can produce high amplitudes of vibration in the intermediate shaft. Such cases can be cured by replacing one of the flexible couplings by a Hooke's joint. If the characteristics of the system are understood, however, this form of trouble can be avoided in the design stage.

The judicious use of rubber in a shaft coupling can be beneficial for a number of reasons: (1) the elimination of one lubrication point; (2) introduction of torsional flexibility; this provides some measure of frequency control, while the rubber effects a limited degree of damping; (3) a degree of axial flexibility is provided.

This axial flexibility makes the use of a sliding spline unnecessary. In fact, its use could be dangerous, since in practice it is usually the case that the spline slides only when little or no power is being transmitted. As soon as the torque builds up, the spline resists any tendency to slide (due to frame deflection, or the like), and this can result in bearings, etc., being overloaded. If the sliding joint has any clearance, the individual male and female splines can in extreme cases " walk " up each other, the resulting displacement producing phenomenal end loads, enough to disrupt a rubber flexible joint, with catastrophic results.

FRICTION

There are many points in a drive where the medium of torque transmission is friction and nothing else. For example, where torque reaction is transmitted from one section of, say, a reduction gear casing to another, some form of spigot or dowel location is usually provided to ensure alignment of bearings. This is rarely sufficiently robust to accommodate the torque loading; friction at the joint does this.

Now, consider the case of a simple flanged joint in a power transmission shaft. Fitted bolts or dowels are provided, nominally to transmit maximum torque through the medium of shear stress. In order to develop shear stress, one flange must tend to rotate relative to the other. Were this relative rotation to be permitted, even if only of a microscopic order, the coupling would suffer from fretting and would probably fail eventually. The normal practice is to tighten the coupling bolts sufficiently to prevent movement. The drive then is being transmitted entirely by friction. Why not design in the first place on the basis of a friction drive?

And why despise the simple belt drive for low-power transmission? In multiple form it is reliable and light, and it will not transmit high-frequency vibrations and will damp low-frequency vibrations. Above all, it is cheap !

LAUNCHES AND TRIAL TRIPS

M.S. " TABRIZ."—Single-screw oil tanker, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for Wilh. Wilhelmsen, Oslo, Norway. Main dimensions: 526 ft. between perpendiculars by 69 ft. 9 in. by 39 ft. 3 in.; deadweight capacity, about 18,000 tons on a draught of 30 ft. 5 in.; oil-tank capacity, about 863,000 cub. ft. Eriksberg-B. and W. eight-cylinder two-stroke single-acting oil engine, developing 10,000 b.h.p. at 115 r.p.m. Speed in service, 16½ knots. Launch, March 4.

M.S. " FLEETWOOD LADY."—Single-screw trawler, built by Cochrane and Sons, Ltd., Selby, Yorkshire, for the Boston Deep Sea Fishing and Ice Co., Ltd., Fleetwood. Main dimensions : 127 ft. 6 in. between perpendiculars by 26 ft. 6 in. by 13 ft. Five-cylinder direct-reversing Diesel engine, developing 700 b.h.p. at 225 r.p.m. in service, constructed by British Polar Engines, Ltd., Glasgow, and installed by the Drypool Engineering and Dry Dock Co., Ltd., Hull. Launch, March 6.

M.S. " CYGNUS."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for Sociedad Transoceanica Canopus, S.A., Panama. Main dimensions: 496 ft. between perpendiculars by 67 ft. 6 in. by 36 ft. 5 in.; deadweight capacity, about 16,300 tons on a draught of 29 ft. 1 in. N.E.M.-Doxford five-cylinder single-acting two-stroke oil engine developing 5,500 b.h.p. at 115 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, about 14 knots. Launch, March 6.

H.M.S. " DUNKERTON."—Twin-screw coastal minesweeper, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for the Admiralty, London, S.W.1. Main dimensions: 152 ft. by 28 ft. 9 in. by 14 ft. 9 in.; armament, three small guns. Diesel propelling machinery supplied by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire. Launch, March 8.

S.S. " DAVID POLLOCK."—Single-screw self-trimming collier, built by Hall, Russell & Co., Ltd., Aberdeen, for the North Thames Gas Board, London, W.8 (Managers: Stephenson Clarke Ltd., London, E.C.3). Main dimensions: 320 ft. between perpendiculars by 46 ft. by 22 ft. 4 in.; deadweight capacity, 4,600 tons on a draught of about 20 ft. Triple-expansion engine of reheat design, developing 1,275 i.h.p. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Steam generated by two oil-fired cylindrical boilers. Launch, March 9.

M.S. " SUMBAWA."—Single-screw cargo vessel, with accommodation for twelve first-class passengers, built by the Nakskov Shipyard, Ltd., Nakskov, Denmark, for the East Asiatic Co., Ltd., Copenhagen, Denmark. Main dimensions: 456 ft. between perpendiculars by 63 ft. 6 in. by 38 ft. 3 in. to shelter deck; deadweight capacity, about 10,500 tons on a draught of about 27 ft. 1 in. Seven-cylinder single-acting two-stroke Diesel engine developing 8,200 b.h.p. at 115 r.p.m., constructed by Burmeister and Wain, Ltd., Copenhagen. Speed, 17 knots, fully loaded. Trial trip, March 12.

M.S. " OCTAVIAN."—Twin-screw oil tanker, built by Swan, Hunter, and Wigham Richardson Ltd., Wallsend-on-Tyne, for Mr. Hilmar Reksten, Bergen, Norway. Main dimensions: 625 ft. between perpendiculars by 86 ft. by 46 ft. to upper deck; deadweight capacity, 31,370 tons on a draught of 34 ft. 6 in.; gross tonnage, 20,178; oil-tank capacity, 1,439,132 cub. ft. Two Wallsend-Doxford five-cylinder two-stroke opposed-piston oil engines, together developing 11,000 b.h.p. at 116 r.p.m., constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 14½ knots. Trial trip, March 15.

H.M.S. "APPLETON."—Twin-screw coastal minesweeper, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for the Admiralty, London, S.W.1. Main dimensions: 152 ft. by 28 ft. 9 in. by 14 ft. 9 in.; armament, three small guns. Diesel propelling machinery supplied by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire. Trial trip, March 18.

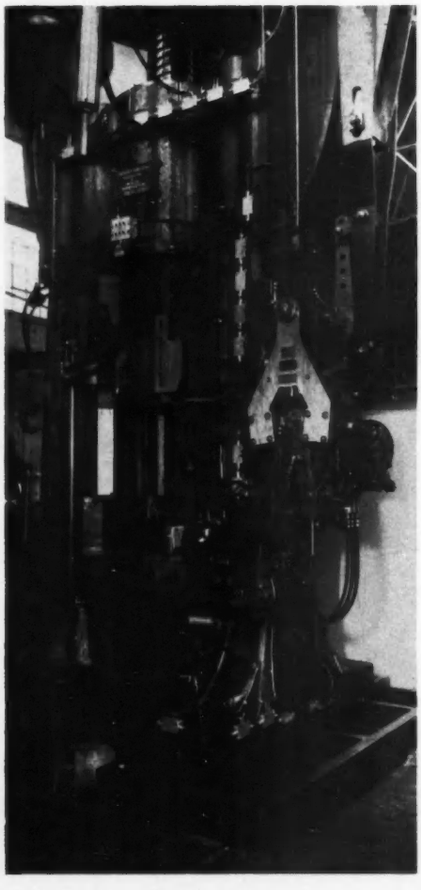
S.S. " NORDVEST."—Single-screw oil tanker, built and engined by Smith's Dock Co., Ltd., South Bank-on-Tees, for the Bergen Kulkompani A/S, Bergen, Norway. Main dimensions: 315 ft. between perpendiculars by 47 ft. 6 in. by 21 ft. 3 in. to harbour deck; deadweight capacity, 4,071 tons on a draught of about 19 ft. 7 in. Fredriksstad steam engine, developing 1,600 i.h.p. Steam supplied by two multitubular oil-burning boilers. Speed about 12 knots in service. Trial trip, March 22.

SCREW PRESS WITH POWER-ASSISTED CONTROL GEAR

The power-driven screw press, on which both the length of stroke and force of blow can be varied, is widely used in industry, particularly in the production of hot non-ferrous metal stampings. The basic principle of the press is well known. A screw carrying the slide and top tool is rotated by one of two friction discs, which are so mounted that they can be moved laterally to make contact with a flywheel keyed to the top of the screw. In the smaller sizes of press, movement of the shaft carrying the friction discs is effected by hand, through the medium of a control handle and levers, but in the larger sizes it is necessary to operate the control gear by power. The latest addition to the range of screw presses made by Taylor and Challen, Limited, Derwent Works, Birmingham, 19, which is of 450 tons rated capacity, has a patented mechanical drive to the control gear. In addition, special provision has been made for the positive centralisation of the driving discs, to prevent " wandering " of the shaft which carries them, when the press is idle with the main-drive motor running.

CONSTRUCTION OF THE PRESS

In basic design the press is orthodox, as the drawing of it shows. A one-piece steel casting, with 7-in. diameter steel tie-bars passing right through it, forms the main body of the press, and cast-steel brackets are used to support the driving shaft and friction discs. The press is mounted on a heavy cast-iron bedplate, which is designed to be concreted in the foundations, and to provide a larger surface for the effective control of vibration. The main screw, which carries the slide, is 11 in. diameter, of specially-designed stub Acme form, with four starts, and works in a phosphor-bronze nut 3 ft. 4½ in. long in the upper part of the press body. This nut is itself screwed into the body, and keyed in position. Screw-cutting of the body, which weighs approximately 16 tons, was carried out in an Asquith 4½-in. horizontal boring machine at the same setting as the boring operation.



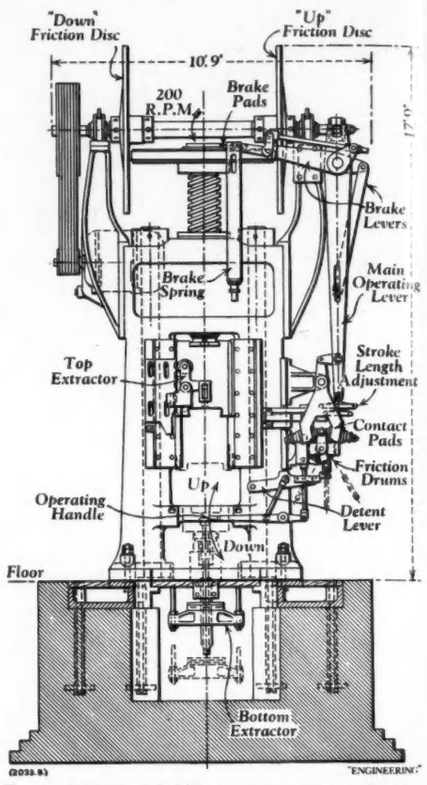
Front of the Taylor and Challen screw press, showing the power-assisted control gear.

The slide, which has a maximum stroke of 22 in., leaves 14 in. of " daylight " at its lowest position for tooling. When the slide is lifted by the screw, the weight is taken by a Hoffmann spherically-seated thrust race; the force of the blow on the down stroke is transmitted through a hard phosphor-bronze pad. The slide is guided by four machined faces on the press body, which are arranged radially from the vertical centre-line. Matching faces on the slide carry adjustable gunmetal wearing strips, 4 ft. 3 in. long, 4 in. wide, and ½ in. thick. The radial arrangement of the guides ensures that relative movement due to expansion when working hot components is across the guide faces, and there is no possibility of binding.

FRICTION DRIVE

A heavy cast-steel flywheel, 4 ft. 11¾ in. in diameter, is keyed to the top of the screw, and faced on its periphery with Hendry buffalo-hide laminated belting to provide a friction surface. Mounted on a shaft above the flywheel are the two friction discs, which are of cast-iron, 5 ft. 6 in. in diameter, and have polished working faces. They are keyed to the shaft, and each is provided with a small amount of lateral adjustment by means of locknuts. The shaft is carried by Hoffmann roller bearings, with wide inner races, which were fitted by heating them to 100 deg. C. in oil, and shrinking them on. Movement of the shaft to enable the friction discs to come into contact with the flywheel is effected by a lever extending down to the control gear on the side of the press body, a Hoffmann double angular-contact bearing being fitted at the end of the shaft to take the thrust. The drive to the shaft is by eight ⅞ in. V-belts from a 35-h.p. electric motor, running at 960 r.p.m., mounted on a pivot at the back of the press body to provide a means of belt tensioning.

Control is by a single hand-lever at the front. Movement of this lever, up or down according to the direction in which it is desired to move the slide, operates the power-assisted control gear, and so moves the drive-shaft sideways to bring the appropriate friction disc into contact with the flywheel. Power for operating the control gear is provided by a 2-h.p. electric motor, running at 720 r.p.m., carried by a bracket from the side of the press body. This drives, through V-belts and a pair of spur gears, a bevel pinion which engages with bevel gears on two coaxial friction drums. These friction drums, because of their coaxial mounting and the fact that they are driven by the same bevel pinion, are contra-rotating. Movement of the control lever operates, through toggles, one of two brake-bands acting on the drums, and so causes the brake band and a swinging cradle, to which it is attached, to move through an arc. In swinging, the cradle carries with it a roller which operates between two spring-loaded contact pads on a fork-ended lever. The cushioning effect of the spring-loaded pads causes the lever to swing



Front elevation of 450-ton screw press, showing foundations and principal features.

smoothly but firmly to the left or right, according to which brake-band has been engaged, and to move the long lever which extends down from the drive shaft. The latter is thus moved sideways until the appropriate friction disc is in contact with the flywheel, which rotates, and drives the screw into the nut in the press body, so moving the slide. This method of control still leaves the slide free to rebound at the bottom of the stroke. A supplementary foot-controller can also be provided.

VARIABLE FORCE OF BLOW

The force of the blow struck by the press is controlled by the way in which the hand control lever is used. A light momentary downward movement of the lever will cause a correspondingly light blow to be given, while a sustained downward movement of the lever will allow the drive to the flywheel to continue to the last possible moment, and the press will then deliver the maximum blow of which it is capable. " Inching " of the slide can also be carried out, and the direction of movement of the slide can be reversed at any point in the stroke by moving the control handle to the required direction. To ensure that the control gear returns to its neutral or central position when the handle is released, and that it remains there, a detent lever is connected to the hand-lever. This detent is spring-loaded to move to its " up " position. When the hand-lever is released, and moves upwards, the detent engages it in the neutral position and holds it there. No movement of the control gear is then possible until the hand-lever is operated once more. In the past a method of keeping the slide at the top of its stroke was to employ the " up " friction disc as a brake, which resulted in the wearing of flats on the flywheel friction surface. The present method of control, however, incorporates an independent brake on the flywheel, and the detent lever effectively prevents the drive shaft from " wandering " and so eliminates the possibility of flats appearing on the friction surface. A manually-operated

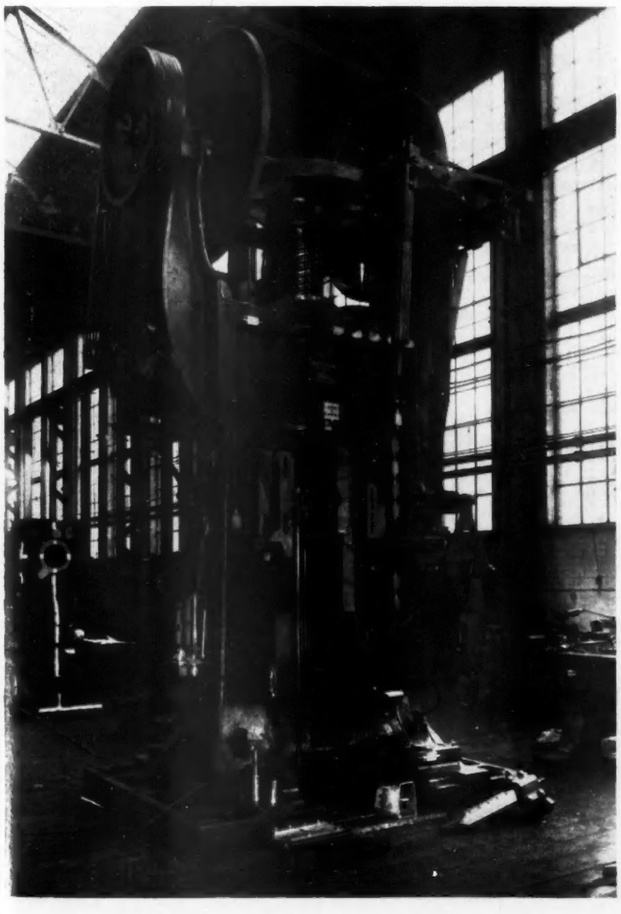
lock is also fitted to the control gear, so that it can be rendered inoperative with complete safety when necessary, as, for example, when small adjustments are being made to the tools.

ADJUSTABLE STROKE

A separate adjustment is provided for setting the length of the stroke to any required dimension, within its limits of 22 in. maximum and 8 in. minimum. This works in conjunction with the brake which stops the flywheel when it reaches its highest position. When the slide is on its return stroke, and some distance before it reaches its top position, the upper face of the flywheel comes into contact with two Ferodo-faced brake pads attached to hinged levers. Pressure on the brake pads is provided by two compression springs mounted in tubes attached to the hinged levers which are keyed to the fulcrum-shaft of the main operating lever. As the flywheel rises and makes contact with the brake pads, the levers carrying them move the main operating lever, which sets the control gear in its neutral position. The two friction discs are thus brought to a central position, out of contact with the flywheel. The two compression springs not only provide progressive braking, but also give a positive pressure to the swinging cradle of the control gear, to hold it against the detent, and so ensure stable conditions.

To provide an adjustment to the stroke length, the brake lever is connected to a screwed rod, which terminates in two hand-wheels working against a cross-piece on the main drive-shaft operating lever. Adjustment of these two hand-wheels, one of which is used for varying the effective length of the screwed rod, and the other for locking purposes, raises or lowers the brake pads, and so causes them to make contact with the flywheel at a different point in its vertical travel. In their highest position, the brake pads arrest the movement of the flywheel at the top safe limit of its travel, and, starting from this position, the flywheel can then make the maximum stroke of 22 in. This stroke can then be reduced as required simply by lowering the brake pads.

Double extractors are fitted, one in the slide, and one in the bed of the press, for removing articles which tend to remain in either the top or the bottom tool. The top extractor is operated by cam-plates on the press body and levers on the slide, while the bottom extractor is carried by a yoke suspended by tie-rods from the lower part of the slide. The lower extractor is arranged so that the work is lifted out of the die during the early part of the up-stroke. The extractor then falls back to its lowest position, leaving the component loose and the die ready for use. Accommodation for tools consists of a dove-tail slot or T-slots for clamping bolts in the slide, and a machined bed in the press body, with four T-slots and a replaceable steel centre-pad, 18 in. diameter by 10½ in. deep. This centre-pad has the advantage of being renewable in case of wear or accidental damage, and it can be machined to suit various types of tooling. The avoidance of a solid mass of metal at this part of the press body also helps to ensure a sound casting. Lubrication is centralised, there being two spring-loaded piston-type lubricators with hand-operated pumps, fixed on the side of the press body. One of these units supplies oil to the screw and slides; the other provides grease for all the remaining working parts.



The control handle, stroke-length adjustment and power-assisted control gear are grouped on the right-hand side of the press.

ALTERNATIVE MEANS OF CONTROL

The first of the present batch of presses has been built for export to the U.S.A., and is fitted with compressed-air control, working in conjunction with the normal hand-lever and power-assisted gear. It will be used for quantity-production of various components, and once it has been set up for a particular operation, it will run for long periods without alteration. The hand-control lever, which continues fully operative, and unaffected by the compressed-air equipment, will be used for setting purposes. The press will then be worked by means of a compressed-air cylinder which is coupled to the hand-lever, and controlled by a shrouded foot-valve. For use with the compressed-air control, an extra cam-plate is provided on the slide, to engage a roller at the bottom of the stroke which trips the connection between the control and the air cylinder, allowing the slide to return to its top position in the normal way. The cam-plate is adjustable so the bottom of the stroke can be set to suit the tools.

CONTRACTS

Passenger Air Liners. The de Havilland Aireraft Co. Ltd., Hatfield, Hertfordshire, have received orders for seven Heron Series-2 aircraft from Devlet Hava Yollari (Turkish State Air Lines). Six of the machines will be 15-passenger air liners and the remaining one, an executive model, will seat eight passengers. The Heron has an all-up weight of 13,000 lb. and is powered by four of the firm's Gipsy Queen 30 Mark 2 engines, each of 250 b.h.p. Delivery of the first aircraft is expected to take place this spring.

Rear-Dump Trucks. Euclid (Great Britain) Ltd., Industrial Estate, Newhouse, Lanarkshire, have received an order for forty 15-ton rear-dump trucks for the Swedish Government. They will be propelled by 180-h.p. Rolls-Royce oil engines, and delivery will commence in a few weeks' time. The vehicles will be used by the Swedish Royal Board of Waterfalls, primarily on the construction of hydro-electric installations.

Equipment for Port Communication. The Marconi International Marine Communication Co. Ltd., Marconi House, Chelmsford, Essex, have received an order from the Tees Conservancy Commissioners for the extension of the present very-high-frequency port-communication equipment to include a further five vessels. The present system, installed in 1949, consists of three of the firm's "Seaphone" transmitter-receivers, one fitted ashore and the other on board the pilot vessel B. O. Davies and the Customs tender Argus. The latest order calls for the installation of Seaphones on board two tugs, two self-propelled hoppers, and a motor launch, and the provision of ancillary equipment.

Turbo-Alternator for Steelworks. The General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2, have received an order for a 2,500-kW back-pressure geared turbo-alternator set for the Margam Works of the Steel Co. of Wales Ltd. The turbine is to operate under steam conditions of 600 lb. per square inch pressure, 800 deg. F. total temperature, with a back pressure of 165 lb. The alternator will generate current at 11 kV, three-phase, 50 cycles. McLellan and Partners are the consultants for the Steel Co. of Wales.

Road Bridge in Iraq. Dorman, Long and Co. Ltd., Zetland-road, Middlesbrough, are to construct a new road bridge over the River Euphrates for the Government of Iraq Development Board. The site of the bridge is at Hindiya, 65 miles south of Baghdad and close to the spot where ancient Babylon once stood. The bridge will be 570 ft. long and 46 ft. wide, and will have a steel central span with reinforced-concrete approaches. The piers will be of steel-piled construction. The total weight of the steelwork is 1,500 tons and the bridge is to be completed within 18 months from the commencement of construction. The consulting engineers are Maunsell, Posford and Pavry.

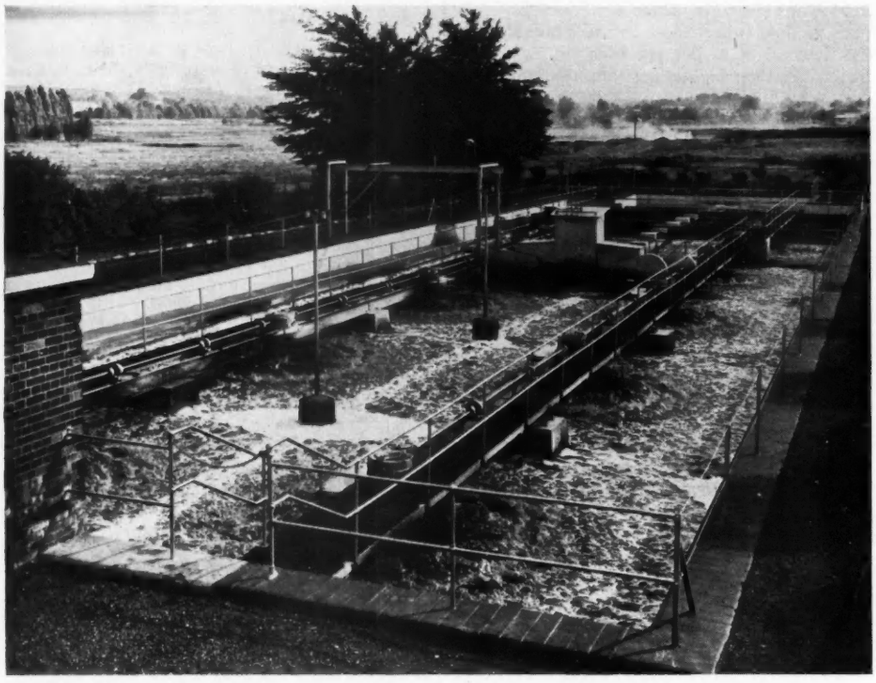
Plant for Making Town Gas from Petroleum. The Power-Gas Corporation Ltd., Stockton-on-Tees, announce that their Australian subsidiary concern has secured a contract from the Petroleum and Chemical Corporation (Australia) Ltd., of Sydney, for the design, manufacture, installation and putting to work of a large plant to make high-grade town gas from heavy petroleum oil along with the recovery of by-products. The technical planning and plant design will be done at Stockton-on-Tees but much of the bulky fabricated-steel equipment will be manufactured in Australia.

Building of Television Transmitting Station. Higgs and Hill, Ltd., Crown Works, South Lambeth-road, London, S.W.8, have been entrusted by the British Broadcasting Corporation with the first stage of the building work at the new London television transmitting station at the Crystal Palace, Sydenham.

Oil Tanker for Norway. Joseph L. Thompson and Sons, Ltd., Sunderland, have received an order from Olsen and Ugelstad, of Norway, for a tanker of 18,000 tons deadweight capacity. The new ship will be delivered in 1956 and will be a sister ship of a vessel already on order at this shipyard for these owners, to be delivered next year.

Ammoniacal-Liquor Plant. W. C. Holmes and Co. Ltd., Turnbridge, Huddersfield, are to supply, deliver and erect a concentracted ammoniacal-liquor plant at the gasworks in Swindon Works, Western Region, British Railways.

Electric Railway Equipment. The Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester 17, have received a contract worth £7,000,000 from the Central Railway of Brazil for 200 complete railway coaches to be built and equipped in this country, and 100 sets of electrical equipment for fitting to coaches to be built in Brazil.



The Epsom and Ewell aerating tank has twelve high-intensity aerating cones driven through shafting; the preliminary-settling tanks are at the far end. Much of the frothing is due to detergents, its occurrence increasing as purification proceeds.

HIGH-INTENSITY AERATION OF SEWAGE

CAPACITY OF TREATMENT PLANTS INCREASED

The "Simplex" system for the surface aeration of sewage being purified by the activated-sludge process was introduced by Ames Crosta Mills and Company, Limited, Heywood, Lancashire, in the early 1920's, since when a great many plants using this system have been installed both in this country and abroad. Plants have been installed for treating small flows of about 5,000 gallons of sewage a day and the far larger flows of great cities. The Simplex system consists of a series of tanks in which the operations of screening, preliminary settling, surface aeration and final settling are performed. It is in the method of bringing about aeration that there has recently been much improvement.

HIGH-INTENSITY AERATING CONE

After passing through screens the sewage enters the preliminary-settling tanks which are usually of the hopper-bottomed or inverted-pyramid type. The sludge, which is by no means the total content of suspended matter, falls to the bottom of the tanks and is drawn off by means of sludge pipes operating under a hydrostatic head.

After settling, the sewage, still containing a quantity of suspended matter, is passed to the aerating tank in which the numerous species of bacteria, protozoa and other microscopic organisms, given suitable conditions, break down the impurities in the sewage and convert them to inoffensive liquids, gases, and sludge. It is in this tank that the aerating cone is used, and illustrated on the right is one of the firm's new high-intensity aerating cones.

The aerating tank of the Epsom and Ewell sewage purification plant, shown above, is the first larger plant of this type to be constructed with a Government grant; it was brought into use in 1925 with a designed capacity for the treatment of 750,000 gallons of sewage a day under dry weather conditions, and in 1952 the original aerators were replaced with high-intensity cones which were put into operation in early 1953. The cones are arranged in two lines and are driven by two independent electric motors located centrally, the drive being taken through two lines of shafting and reduction gears.

The aerating tank is divided into twelve pockets in the form of inverted truncated pyramids. In each pocket there is a stationary uptake tube surmounted by a high-intensity cone which is suitably vaned to draw water axially up from the bottom of the pocket and to pour it outwards radially over the surface. The pockets are connected in series and the arrangement ensures that the sewage is aerated by each cone in turn, and during this process it is, of course, rapidly circulated and turned over in each pocket a great number of times.

After aeration, the treated sewage is passed to the final settling tanks, which do not appear in the illustration of the Epsom plant. From these tanks the clear purified liquid is run off, leaving the bacteria-charged sludge behind to be removed and subsequently used as fertiliser or passed back to the aerating-tank. It is fundamental to the activated-sludge process of sewage purification that some of this sludge is passed back to activate the incoming suspended matter and so accelerate the whole process of purification by aeration and bacteriological action.

INCREASING THE CAPACITY OF EXISTING PLANT

Prior to the development during the last five years of the high-intensity cone, it was the practice to use a cone which threw out the sewage more in the form of a sheet of liquid, whereas the high-intensity cone is designed to lift a large volume of sewage and to pour it out in a heavy torrent. A high degree of turbulence results and a wave action which moves outwards over the entire surface of a pocket is created; the surface area of liquid in contact with atmospheric oxygen is increased while the dissolved oxygen is quickly and evenly distributed as a result of the rapid turning-over which occurs.

The makers claim that, by using high-intensity cones, the capacity of a plant to treat sewage is increased by 50 per cent. It is reported that at the Bury sewage works a number of the old-type cones was replaced by the new high-intensity type and the two installations then worked side-by-side with independent arrangements for the return of bacteria-charged sludge from the final settling tanks to their respective aerating tanks. Separate records of the performance of the two independent installations were kept and the

The high-intensity aerating cone made by Ames Crosta Mills and Company, Limited, lifting sewage axially and pouring it out radially, thereby causing rapid turn-over and absorption of atmospheric oxygen.

table produced here, from data supplied by Mr. G. R. C. Marsden, illustrates how, when high-intensity cones are installed, the time required for aeration may be reduced by one third, or conversely, the quantity of sewage per cone may be increased by one half.

Comparative table of results obtained over two periods from sewage-aeration plants using the new high-intensity and the older types of aerating cones.

—	October 21, 1946, to August 29, 1947		September 1, 1947, to August 10, 1948	
	High-intensity cones	Old-type cones	High-intensity cones	Old-type cones
Average daily flow per cone. (Gallons) ..	61,200	40,600	60,600	40,400
Average aeration period. (Hours)	12·8	19·2	12·9	19·4
Percentage of increase in flow for high-intensity cone	51	—	50	—
Average of oxygen absorbed in four hours by effluent. (Parts per million)	19·0	19·8	23·7	23·5

The Bury sewage is stated to be one of the strongest in the country as it contains a quantity of trade effluents from tanneries, fellmongeries, breweries, and textile and other works.

The ability to be able to reduce the time of retention for aeration by one third has, of course, a number of advantages, since it makes it possible to increase the capacity of existing surface-aeration installations by 50 per cent. without making any structural alterations. It also leads to an economy in first cost as, for a given capacity, a smaller plant is needed, and working on a period of retention of 11 hours, four pockets each to hold 68,750 gallons and occupying not more than 4,000 sq. ft., are sufficient to treat the normal domestic sewage of a town with a population of 20,000.

GAS-FIRED PLANT IN AN AERO-ENGINE WORKS

The South Western Gas Board includes among its industrial consumers a number of firms manufacturing aircraft components and equipment. One of their biggest consumers is the engine division of the Bristol Aeroplane Company, Limited, Filton, Bristol, with an annual consumption of 270 million cub. ft. of gas.

In the Bristol Company, gas is used extensively throughout all stages of turbine and piston-engine production except machining. It is employed in the heat treatment of major steel components such as crankshafts, propeller shafts, master rods and cylinder sleeves; it provides the source of heat for melting magnesium and aluminium to be cast as front and rear engine covers and compressor casings; and it is used in stove enamelling, plating, de-greasing, rust proofing, precision casting, forging turbine blades, and general foundry work.

The need for new installations is continuous, and the South Western Gas Board has its own depot in the engine division to facilitate liaison with the Company's technical staff and to maintain all gas-fired plant in working order.

In the heat-treatment and enamelling shops are treated components both for turbine and piston engines, and the gas consumed amounts to 106 million cub. ft. per annum. The processes and plant include carburising furnaces for pack-hardening mild steel parts, a refining furnace for refining and hardening components, tempering tanks, cyanide furnaces for surface-hardening steel components, a 700-gallon boiling-water quenching tank, brazing of copper cylinder heads, melting flux and silver solder, enamelling ovens, plating vats, rust-proofing or cadium-plating tanks, and wash-off tanks.

Perhaps the most interesting application of gas at Bristol is in the precision foundry, which is engaged on the production of components for turbine engines by the lost-wax process. Some 20 million cub. ft. of gas are consumed a year in this department.

An extremely high standard of surface finish is achieved at the Bristol foundry, resulting mainly from the use of patented processes in applying the primary coating and in moulding. Ordinary Portland cement and water are used as the binding agent for the refractory moulding material.

The dies in which the wax patterns are formed are either of machined steel to ensure the durability essential for quantity production, or, when small numbers only of a part are required, of a low melting-point metal. The patterns are made from dental wax, injected into the dies at temperatures of 75-80 deg. C. Stabilisation of room temperature is essential in the wax injection room; a gas-fired steam boiler is employed to heat the air, which is maintained at 65 deg. F.

From the injection machine the patterns pass to bays where they are sprayed with primary and secondary refractory coatings, and then go by overhead conveyors to the investment room. Here, the patterns are invested in containers and the moulds so formed are first vibrated to consolidate the investment material and then gently heated for 8 to 10 hours to cure the moulds and to melt out the wax. Four gas-fired ovens, supplied by the J.L.S. Engineering Company, Limited, Birmingham, in which air is circulated, are used for this stage.

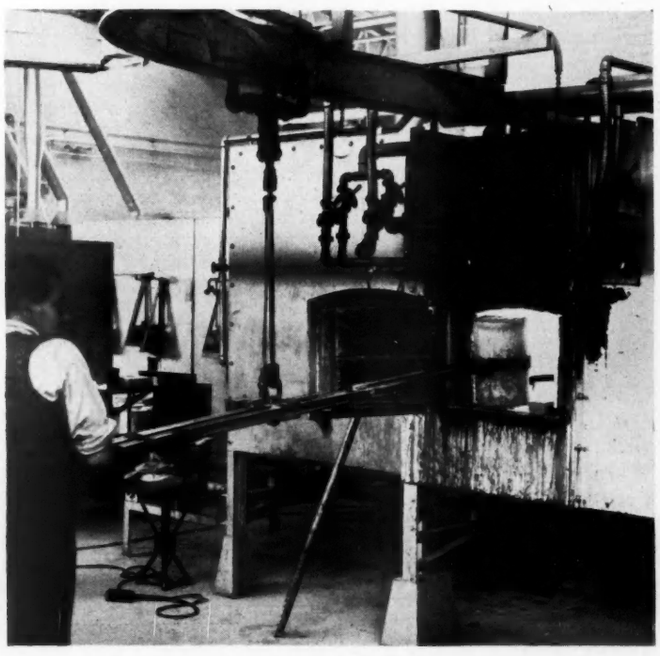
The moulds are loaded on trolleys which carry them slowly through 30-ft. gas-fired bogie furnaces constructed by the Franklin Furnace Company, Limited, Birmingham, to a design developed for the Bristol company by the South Western Gas Board. In these furnaces the temperature increases gradually from 250 deg. C. to 1,150 deg. C. over a period of four hours. When the requisite temperature and time of firing are reached, each mould, still red hot, is taken out by long tongs, as shown in the accompanying illustration. Molten metal is then poured into the moulds and dense compacting even at the thinnest sections of a casting is assisted by air pressure. The moulds are then removed for cooling and the cement is later broken away from the casting. Even at this stage, before final machining, a high standard of surface finish is apparent.

In the magnesium and aluminium foundries components are cast both for turbine and piston engines and for the power unit of the "Bristol" two-litre car. The gas consumption amounts to 26 million cubic feet per annum. For magnesium and zirconium melting a number of pit-type furnaces are installed, ranging from 100 lb. to 600 lb. capacity, together with furnaces for heating tools before stirring and skimming. Burner equipment made by British Furnaces, Limited, Chesterfield, is installed on all units.

For aluminium melting, the plant comprises two 300-lb. capacity lip-axis tilting furnaces, one 300-lb. pit-type furnace with lift-out pot, one 300-lb. bale-out furnace for gravity die-casting, one high-temperature crucible furnace for melting cast-iron chills used in moulding sand castings, and two pre-heater ovens for crucible ladles.

For general foundry operations, the following equipment is in use: an Acme tower core-drying oven fired by a Selas radiant flame burner, gas-heated Ballard core-drying ovens, gas-heated sand dryers, an overhead radiant-heating mould heater which skin-dries moulds in seven minutes, and gas torches for skin-drying moulds.

In the blade-forging shop, where compressor blades for the Olympus and Proteus engines are forged, seven gas-fired furnaces supplied by British Furnaces, Limited, and Brayshaw Furnaces and Tools, Limited, Manchester, are used to heat steel blanks for drop-stamping turbine blades. Gas-fired water-spray equipment is employed for washing acid from the blades. The shop-heating system comprises ten Aerozone gas-fired air heaters made by Radiant Heating, Limited, and 15 wall-panel heaters made by Thos. De La Rue and Company, Limited, Potterton Gas Division. Special burners are employed for pre-heating the drop-stamping dies.



Removing a cured mould, formed by the lost-wax process, from a 30-ft. gas-fired furnace in the precision casting foundry.

The caisson gate of the King George V dry-dock, Southampton, berthed in No. 3 dry-dock for its first major overhaul since its installation in 1933.

DRY-DOCKING A CAISSON GATE

The operation has recently been completed of removing and dry-docking for major overhaul the caisson gate of the King George V dry-dock at Southampton. It is now in No. 3 dry-dock for repairs, renewal of the greenheart-timber meeting faces and the examination, cleaning and painting of all the interior and exterior steelwork not normally accessible. Work in progress is shown above.

This is the first time that the caisson has been dry-docked since 1933, when it arrived in tow from the builders, the Furness Shipbuilding Company, Limited, Haverton Hill-on-Tees.

When the present overhaul was first planned it was intended that the caission should be taken to the No. 6 (Trafalgar) dry-dock, where it could have been cradled in its normal upright position. This would have meant, however, that Southampton's two largest dry-docks – the King George V and the No. 6 dry-dock – would have been out of commission. It was therefore decided to use the small No. 3 dry-dock though this involved turning the gate over on to its back. In this position it has a draft of only 13 ft. as compared to 31 ft. 9 in. when upright.

The caisson gate is of the steel-box sliding type with greenheart meeting faces which form a watertight joint when pressed against the accurately dressed granite-meeting faces, or stops, of the dry-dock. The gate is double-faced; that is to say, water can be pumped into the dock and the level therein maintained constant irrespective of tide movements in the river as well as the normal action when the dock is pumped dry.

The King George V is opened and closed by sliding the caisson in and out of a camber or recess at the side of the dock entrance. Provision has been made in the layout of the entrance for the caisson to occupy any one of the three following positions. The normal working position is against the inner stop when water can be excluded from the dock whatever the state of the tide. The second position is against the impounding stop and the caisson is put in this position when it is necessary to maintain the level of the water within the dock. The third is the outer or emergency stop situated at the extreme outside limit of the dock entrance and it is when the caisson is in this position that the dock can be emptied and the steel slide path and caisson camber examined and repairs undertaken.

The principal dimensions of the caisson are: length, 141 ft. 9 in.; breadth, 29 ft. 6 in.; and height, 58 ft. 6 in. When the dock is dry, the total water pressure against the caisson at high tide is about 6,000 tons. The weight of the caisson, including some permanent concrete ballast, is 1,870 tons. The total weight, with the water ballast and in working condition, is 4,690 tons. When the dock is flooded, however, and the caisson is being moved into position, its displacement is about 4,655 tons, dependent on the level of the tide; thus the actual weight on the slide path is only about 35 tons, again depending on tide level.

The caisson is divided horizontally into four main compartments by three intermediate watertight decks. The top compartment is open to the tide, the inner or dock-side skin plating preventing water from entering the dock. The second compartment from the top is an air chamber which contains the pump and piping used for pumping water ballast from the tanks in the next lower compartment. The third compartment from the top is divided into three tanks by two vertical cross bulkheads; in the working condition, all three of these tanks are full of water but they can be emptied by using the pump in the air chamber. If the centre tank or the two end ones are pumped dry the caisson floats with a draft of 37 ft. 6 in. and if all three tanks are emptied the caisson will float with a draft of 31 ft. 9 in., when it will still be stable in the upright position.

The bottom comparment is also normally full of water but if even a small quantity is pumped out the caisson is no longer stable vertically and will take up an inclined position.

As already mentioned, to dry-dock the caisson in No. 3 dry-dock it was necessary to incline it from the vertical to the horizontal position, which meant pumping out most of the water from the bottom compartment. The task of turning the gate over was completed near to its working site and prior to towing into dry-dock. The operation of turning the caisson on its back was a tedious one as the fixed caisson pump cannot be used for de-watering the bottom compartment. To do this, a small portable submersible electric pump had to be lowered through an access trunk to the bottom chamber and it took 12 hours continuous pumping to remove about one half of the water. It was then possible to get a second pump to work and the remainder of the operation was completed in a further seven hours. The total quantity of water removed in the 19 hours was 1,460 tons.

The following is a timetable of the complete operation of moving and dry-docking the caisson:

Thursday, March 4. The water ballast was pumped from the centre tank of third compartment to raise the caisson sufficiently for it to be manœuvred out of its normal position.

Friday, March 5. The caisson was taken out of position and moored alongside the wall of the dock. Water was pumped from the two end tanks of the third compartment, thus completing de-watering of that compartment.

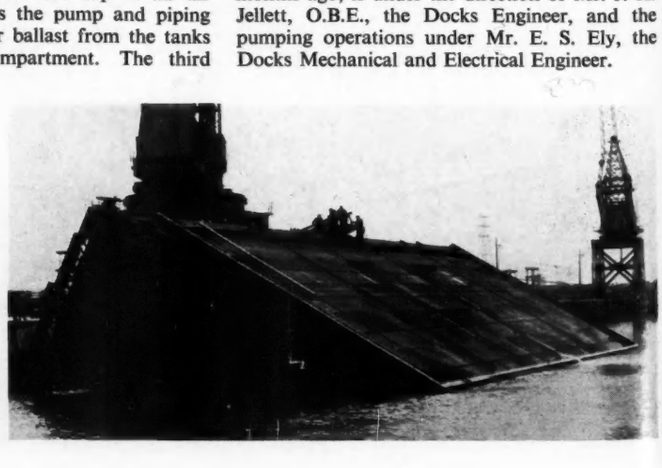
Saturday, March 6. One half of the water was removed from bottom compartment (this involved 12 hours pumping).

Sunday, March 7. All but 10 tons of the remaining water in the bottom compartment were removed (seven hours pumping).

Monday, March 8. 50 tons of iron and steel ballast were placed on the now up-turned side of the caisson to correct tilt, making the caisson truly level and ready for towing.

Tuesday, March 9. The caisson was towed to No. 3 dry-dock and docked on a specially prepared cradle comprising a line of 13 blocks to support the bottom deck of the caisson and two sets of four blocks to support the ends and so spaced to suit the intermediate decks.

The work, the planning of which started six months ago, is under the direction of Mr. J. H. Jellett, O.B.E., the Docks Engineer, and the pumping operations under Mr. E. S. Ely, the Docks Mechanical and Electrical Engineer.



So that the gate could be accommodated in a small dry-dock for repairs, it had to be turned on to its side by pumping out most of the water ballast.

AUTOMATIC CHUCKING MACHINES

WIDE RANGE OF TOOLING ACCOMMODATED BY FOUR AND SIX SPINDLE VERSIONS

Two automatic multi-spindle chucking machines, one, shown in the illustration below, with four spindles and a chuck capacity of 9 in. and the other with six spindles and chucks of 7¼ in. capacity, have been added to the range of automatic machines made by Wickman Limited, Machine Tool Division, Tile Hill, Coventry. Designed for the rapid and accurate machining of castings, forgings, billets and pressings, the new machines, which have been developed from earlier models in the range and incorporate many of their features, are of rigid and heavy construction and both weigh, without tooling, approximately 12 tons.

Power is supplied to each machine by a 30-h.p., 960-r.p.m. electric motor, foot mounted on a hinged platform, and the drive is transmitted by heavy matched V-belts. Twenty-four spindle speeds can be selected, ranging from 29 to 473 r.p.m. on the four-spindle machine, and from 51 to 675 r.p.m. on the six-spindle version. The spindles, which are made from heat-treated steel forgings, incorporate large integral flanges for mounting the chucks, and run in taper and parallel roller bearings. The spindle height, relative to the cross-slides, is 3⅛ in. in the six-chuck version, and 5$\frac{31}{32}$ in. in the other. Each spindle is fitted with a multi-plate clutch and brake.

CHUCKS AND CLUTCHES CONTROLLED BY AIR CYLINDERS

The spindle clutches, brakes and chucks are operated by air cylinders, which are electrically controlled by light-action levers, and their motions are interlocked to prevent the introduction of incorrect settings. The air cylinders, which are of tandem pattern on the six-spindle model and single pattern on the four-spindle machine, have a draw-bar stroke of 1¼ in.

Each cylinder is provided with a combined running joint and valve, also a simple reversing valve for internal and external gripping and a pressure safety switch which automatically stops the feed if the air pressure falls below a pre-set minimum value. The maximum permissible air-line pressure is 100 lb. per square inch and the greatest consumption of free air of either machine operating at that pressure is 7 cub. ft. per minute.

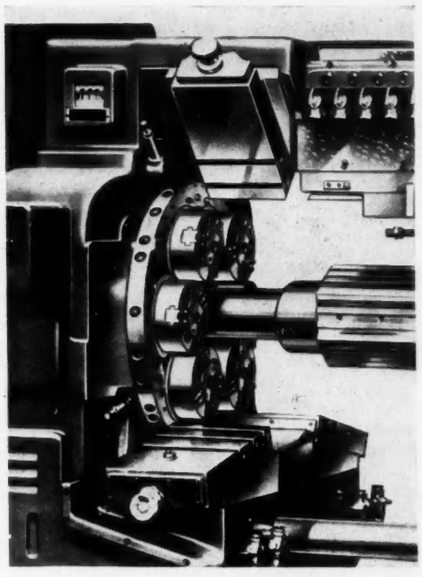
Under normal operating conditions, with no tooling in the loading station, the spindle is automatically stopped, after completion of indexing, in readiness for the removal of the finished work from the chuck. When the machine is prepared for accelerated end-working, with tooling in the loading station, the spindle is stopped only when tools are clear of the work. These automatic actions are effected by means of adjustable timing cams.

Other precautions to ensure the safety of the operator are two-hand push-button controls, which are linked with a warning light system, and a mechanism which automatically disconnects the feed clutch before indexing takes place, if the buttons have not been pressed.

DOUBLE INDEXING

The six-spindle machine, shown in the close-up view, can be arranged to permit double indexing, and loading is then carried out at stations 5 and 6, with separate controls for each station. With this exception, loading is performed at station 6 on the six-spindle machine and at station 4 on the four-spindle model and is right-handed. In both machines indexing is anti-clockwise, so that the heavier roughing operations are carried out at the lower positions.

Both machines are fitted with chucks incorporating interchangeable hardened jaws and wedge angles which may also be exchanged to provide, alternatively, maximum gripping of the workpiece or greatest movement. The standard jaw with a wedge angle of 10 deg. has a travel of 0·22 in. and the special jaw, which has a wedge angle of 15 deg., permits a movement of 0·33 in.



The six-spindle version is similar to the four-spindle chucking machine but can be adapted for double indexing, and accommodates work up to 7¼ in. in diameter.

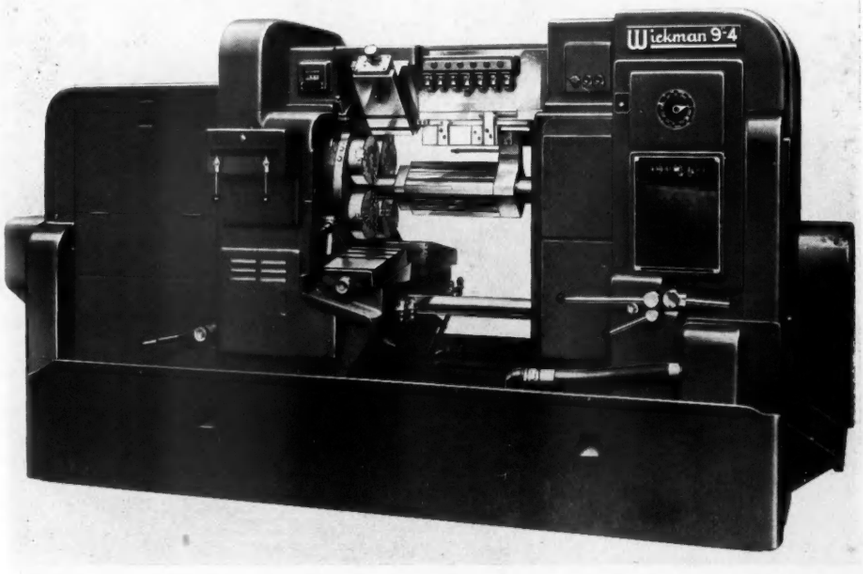
Cross-slides are normally fitted in stations 1 and 2 but can also be added at stations 4 and 5 on the six-spindle machine and at stations 3 and 4 on the four-spindle machine. All cross-slides are provided with micrometer adjustment and a master stop which engages with corresponding screws in the spindle drum. The feed stroke on the lower cross-slides can be of any length up to 1¾ in. and on the upper slides up to 2½ in. In the case of the upper slides, a total feed or idle stroke of 4 in. can in addition be specially incorporated. The idle time is 4½ seconds.

Like their predecessors in the range, the new machines incorporate lever-adjusting mechanisms, by means of which the tool-feed strokes can be altered without changing cams. Tool feeds and speed ranges have been selected to cover the widest field of use and to permit full exploitation of carbide-tipped tools.

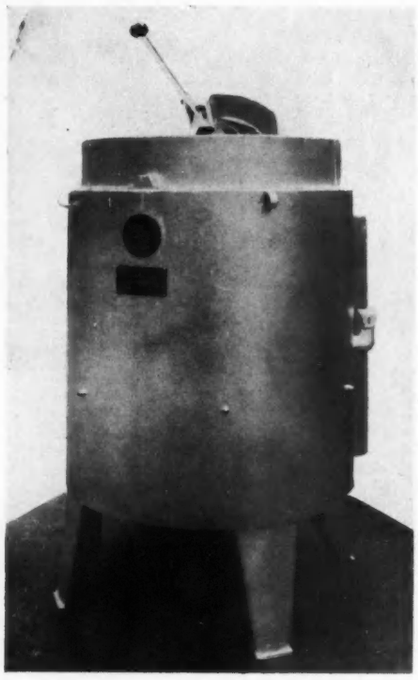
END-WORKING SLIDES

The main tool block, which carries as many slideways as there are stations and has a feed stroke up to 5 in. in length, includes a dead stop and step-by-step longitudinal adjustment, so that its position may be chosen to suit any given set-up. Independent upper end-working slides can also be fitted in stations 4 and 5 on the six-spindle version and in stations 3 and 4 on the four-spindle model, and these have a feed stroke of up to 5½ in. All end-working slides have an idle stroke of 3½ in. and the maximum swing over the faces of the main tool block is 6 in. in both machines. The maximum swing over the nose of the main tool block is 7⅛ in. for the four-spindle machine, and the chuck diameter and maximum swing in front of the main tool block is 9 in. In the case of the six-spindle machine, the chuck diameter and maximum swing are 7$\frac{15}{16}$ in.

A wide range of tools can be accommodated in the tool holders provided, which, in many cases, are interchangeable between stations and are standard for other Wickman machines. Attachments for high-speed drilling, independent reaming and plain threading with self-opening rotating diehead, or full threading with solid taps and dies, are made for both versions of the machine, which occupy a floor space of approximately 4 ft. 11 in. by 13 ft. 10 in.



In this picture of the Wickman four-spindle automatic chucking machine, which can take work up to 9 in. in diameter, may be seen the main tool block and the upper and lower cross-slides. Tool feed strokes are adjusted, without changing the cams, by means of a lever.



Electric furnace for heating components in atmosphere of steam.

STEAM-ATMOSPHERE FURNACES

In order to meet a growing demand for a standard furnace in which a steam atmosphere is used for "blueing" such components as high-speed drills, electrical parts and other articles requiring a rust-resisting finish, Birlec Limited, Tyburn-road, Erdington, Birmingham, 24, have developed a new range of vertical furnaces specially designed for use with a steam atmosphere and capable of operation at temperatures of up to 700 deg. C.

The blackish-blue oxide coating obtained at about 550 deg. C., in addition to being rust resisting, has been found to increase the life of high-speed drills when used for certain purposes, but the main advantage is that components which are produced to precise limits can be heat treated without the need for a final grinding operation after the secondary hardening treatment. Steam atmospheres have also been employed in furnaces for the protection of the surfaces of brass and nickel silver during annealing. A further and more recent application of the steam-atmosphere furnace is for the treatment of ferrous sintered products after the sintering operation. It is claimed that greater hardness is obtained if the components are heated in a steam atmosphere after sintering.

The new steam-atmosphere furnaces, which have been developed from the firm's well-known VFC range, are of the vertical cylindrical type and are built on orthodox lines with a brick-lined steel shell. An interior metal container covers the main brickwork so that the furnace refractories do not absorb the steam. A hand-operated cover is supplied and the lifting equipment is designed in such a manner that no elaborate clamping methods are needed to ensure a gas-tight seal. Insulators are mounted on the inner face of the metal container to carry the electrical heating elements, an arrangement which ensures that heat is imparted directly to the charge by means of the air-circulation system of the furnace. A centrifugal fan and suitable baffles are fitted to ensure temperature uniformity throughout the charge space. Steam is admitted to the furnace chamber near the fan and an outlet is provided at the top of the chamber with drain valves at suitable points. The steam, which need only have a pressure of a few pounds per square inch, can be taken from the normal factory supply or, where this is not available, a separate, small boiler can be provided. All heating elements, lead-outs and other possible sources of leakage, such as the fan shaft, are sealed, and fitted with glands to prevent the escape of steam.

The makers mention that the new furnace can be employed for heat-treatment applications without a steam atmosphere where temperatures up to 700 deg. C. are required. These include the tempering of carbon-steel tools and components, the annealing of copper and brass and the solution treatment of aluminium alloys.

SWAGING MACHINE FOR ARMATURE WIRES

ADAPTED FROM RIVETING HAMMER

To increase the speed with which the windings for fractional horse-power electric motors and generators can be formed and laid in position, the British Vacuum Cleaner and Engineering Company, Limited, Leatherhead, Surrey, have developed a swaging machine the design of which is based on a modified riveting hammer. With the aid of this machine, wires already located in the armature, and extending from it, are bent to shape and pressed into the commutator slots. The riveting hammer, which was made by the Atlas Diesel Company, Limited, Beresford-avenue, Wembley, Middlesex, has been converted into a pneumatic punch and forms the main component of the new machine.

The introduction of the machine, it is claimed, has reduced the time required for swaging and crimping operations, which were formerly performed by hand, by 50 per cent. and has, in addition, improved the quality of the product and also eliminated wastage of solder during subsequent operations.

The manner in which the various items of equipment are assembled can be seen in the photograph. The riveting hammer, which operates at an air pressure of 20 lb. per square inch, is attached to a small arbor press by means of a clamp and is held in a vertical position. The clamp grips the piston-cylinder of the hammer, the riveting head of which is adapted to take a small insert punch. The insert, which may be readily detached, is simpler to replace than the entire punch and the inconvenience caused by breakages is therefore considerably reduced.

In addition, by exchanging one insert for another, the machine may be modified to suit wires of various gauges so that its use may be extended to a wide range of small generators and motors. Serrations in the leading edges of the inserts spread the wires in such a way that they are gripped firmly in the commutator slots and consequently only a comparatively light blow is required to locate them.

Attached to the near side of the clamp, as illustrated, is an extension piece set parallel to the punch. This carries a guide, similar in appearance to a sewing machine foot, which controls the wires extending from the armature and holds them in place as the swaging action of the punch commences. It is therefore necessary that previous operations performed on the armature should leave the wires projecting in such a way that they may be drawn into position by the guide and pressed home into the commutator slots by the punch.

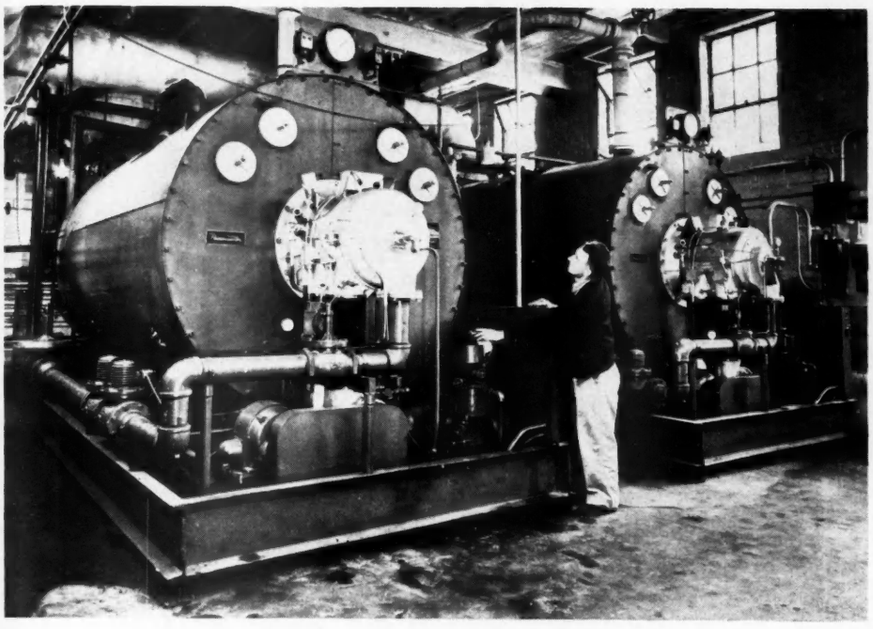
It is necessary for the guide and the punch to meet the wire simultaneously and this is effected by means of a tripping device, which, as the

The swaging machine shown here has been developed from a riveting hammer and is used to set the armature wires of small motors and generators in position and to punch them into place in the commutator slots.

press arm is brought down, depresses the air trigger on the riveting-hammer handle. The tripping attachment is arranged so that it operates the punch at the same moment as the guide touches the wire.

Before the introduction of the machine, when swaging was done by hand, it had been found impossible to ensure constant and controlled punching, so that the results were frequently unsatisfactory and the work had to be repeated. Not only does the new machine ensure a uniform and efficient product but also enables the operation to be completed in two minutes instead of four.

With hand-swaging, spaces were often left in the commutator slots and these gave rise to faulty soldering and hence to the existence of " dry joints." The quality of swaging is so much improved by the use of the automatic punch that, not only is less solder required to complete the joint between wires and commutator, but the increased efficiency of the soldering has practically eliminated armature failure due to dry joints.



Typical installation of two 250-h.p. Powermaster boilers serving a hospital.

A " PACKAGED " BOILER

STEAM-RAISING OR WATER-HEATING

A design of " packaged " boiler for steam-raising and water-heating has been introduced in this country by G.W.B. Furnaces, Limited, Dibdale Works, Dudley, Worcestershire. It is marketed under the name " Powermaster " and is based on the experience of an American firm, Orr and Sembower Incorporated, who introduced these boilers in 1946. They are used for space heating and for supplying process steam. A note on the considerations which led to the production of Powermaster boilers in Britain is given in Weekly Survey in this issue.

The boiler is of the super-economic, horizontal fire-tube type with three-pass gas travel, and is made in various sizes giving steam outputs from 517 to 17,250 lb. per hour. As the diagrammatic view shows, the hot gases pass through a central cylindrical combustion tube to the rear, and then reverse through a lower bank of tubes to the front; finally the gases flow to the outlet at the rear through a third set of tubes arranged in two parallel banks on either side of the combustion tube.

The boiler, complete with all ancillary equipment necessary for operation, including burner equipment, automatic controls, etc., is supplied mounted on a strong steel base. No special settings or foundations are required and the unit, being already piped and wired, only requires the fuel, water, electricity and steam connections to be made to render it capable of immediate operation. Installation costs are thus reduced to a minimum. The packaged Powermaster boiler occupies approximately one half the space required by a unit of conventional design. There is no need for a costly and unsightly stack since a forced-draught fan is fitted.

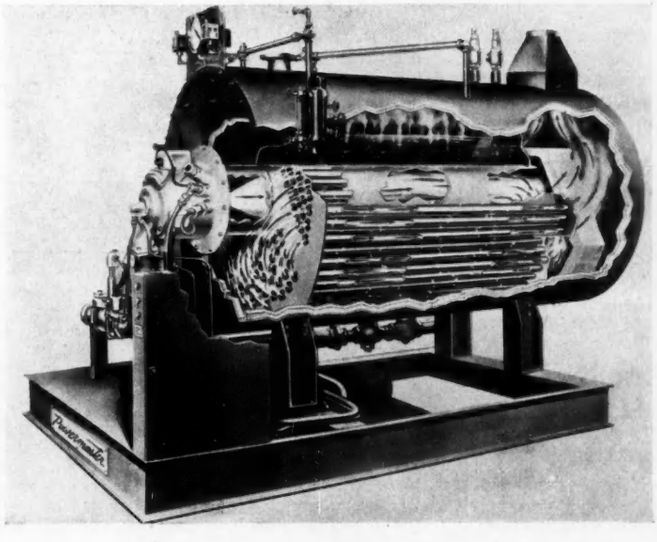
Oil-fired units are fitted with a " Voriflow " air-atomising oil burner which gives, it is stated, an excellent flame pattern, so important in multi-pass boilers, and consistently clean combustion over loads of from 20 to 100 per cent. Fuel oil flows through the central tube of the burner and is picked up at multiple injection points by individual air streams. Only about 1 per cent. of the total full-load combustion air is admitted with the oil for atomisation, thus ensuring a high efficiency during light loads. Among the advantages claimed for the air-atomising type of burner is the low oil pressure required – well under 20 lb. per square inch as compared with up to 300 lb. per square inch for a mechanical pressure atomising burner. The " Voriflow " oil burner is capable of handling fuel oils from light oil with a viscosity of 31 seconds Redwood up to the heaviest oils of 3,500 seconds viscosity.

The " Voriflow " gas burner is of the pre-mix design. The gas flows through a central nozzle from the gas plenum while, at the same time, combustion air from the blower enters an air plenum, automatically controlled by a motor-operated damper. Primary pre-mixing air is directed through holes into the gas nozzle against Venturi-shaped baffles. The outer secondary-air ring controls the quantity of secondary combustion air admitted to the combustion chamber.

A combination oil/gas burner may be fitted if required. It is designed to avoid any complex changes in piping, wiring or other accessories when changing the fuel. Indeed, the changeover can be accomplished in five minutes.

The Powermaster boiler is provided with a full-range " combustion modulation " control system. The effect of this is that at all times, and over 20 to 100 per cent. boiler operating range, the running efficiency is maintained in excess of 80 per cent. The correct fuel/air ratio is maintained to ensure efficient firing at all loads. This modulation control is governed either by a pressure switch, in the case of steam-raising boilers, or by means of a thermostat for water heaters. Adjustable cam positions for the fuel valve and air shutter are pre-set, after preliminary checking, for the correct flue-gas analysis.

Maintenance and cleaning are easily and quickly carried out. The front covers swing clear without having to remove the burner assembly, and the rear cover swings out clear on its davit, so that the entire boiler is easily accessible. Either integral or separate boiler-feed systems are provided.



Diagrammatic view of Powermaster boiler, showing three-pass flow of gases. Advantages of this design are: portability; no special foundations required; compactness; tall chimney stack not required; and high efficiency over a wide load range.

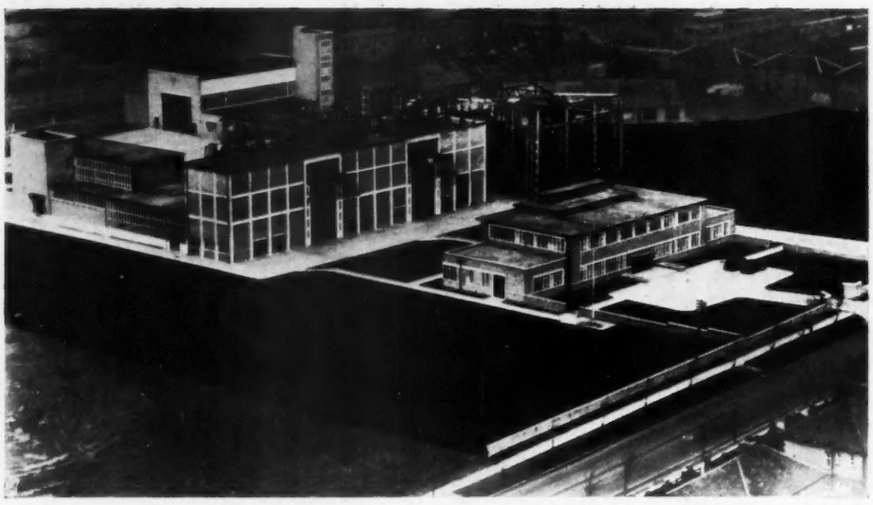


Fig. 1 Exterior of the new switchgear testing station at Hebburn with the test bays on the left and the control room on the right.

TESTING HIGH-POWER SWITCHGEAR

FACILITIES AT HEBBURN EXTENDED

A new research station which has been built by A. Reyrolle and Company, Limited, at Hebburn, Co. Durham, for the short-circuit and allied testing of high-voltage switchgear of large capacity, was formally opened by Lord Citrine on Tuesday, March 23. Its inauguration marks a further stage in this branch of engineering research, as the plant is a descendent of the first regular short-circuit testing in station in Great Britain, which was established by the same firm in 1929. This original station was extended in 1934, its equivalent three-phase output (obtained in single-phase tests) being at that time about 1,100 MVA at 132 kV.

During the last 20 years the demand for switchgear with higher rupturing capacities has grown so rapidly that the limitations of the testing plant sometimes rendered it impossible to produce the most economical design. Although this indicated that larger and more modern equipment would be required, it was also clear that it would be uneconomical to construct a station with short-circuit outputs equivalent, say, to the 10,000-MVA rupturing capacity of a 275-kV circuit-breaker. This difficulty has been overcome by the development of "unit" testing, which is normally carried out on one phase. The primary object of the new station has therefore been to provide the greatest possible single-phase output, although three-phase short-circuits at voltages up to 275 kV can also be set up. The power available will, in fact, enable three-phase, single-phase or unit tests to be carried out on any equipment that is likely to be built in the near future. A serious obstacle from the path of the designer has therefore been removed.

TEST PRINCIPLES

The necessary large outputs indicated above are achieved by taking advantage of the fact that the minimum plant reactance in a single-phase circuit can be obtained by connecting all the transformers in parallel; and by arranging the generator windings in what is known as a U-connection. In this way the reactance is reduced and the output increased by at least 33 per cent. The maximum benefit is obtained from this connection by using over-excitation, thus ensuring a high recovery voltage and a correspondingly large current during the test. Finally, by applying the short-circuit at any selected point on the voltage wave, complete control over the degree of asymmetry can be exercised, while symmetrical tests can be made immediately after the start of the short-circuit and before the sub-transient components of the current have died away.

PLANT ARRANGEMENT

The arrangement of the plant now installed at Hebburn is shown diagrammatically in Fig. 2. It is housed in a series of steel-framed brick and concrete buildings, so arranged that the conductor runs are as simple as possible and easy access is obtainable to all parts. These buildings are grouped about the test-bay block, which also houses the making switch, while the control room is about 100 ft. away. Road and rail access has been provided to all the test areas and the natural fall of the ground has been used to improve observation and to provide protection between the test bays and the safe areas. Fig. 1 shows the station with the test bays on the left and control room on the right.

As will also be seen from Fig. 2, the plant consists of three short-circuit alternators with their associated over-exciter sets. These machines supply power through a master circuit-breaker, current limiting reactors, resistors and a making switch to a group of extra-high-voltage transformers. The alternators are usually paralleled on the extra-high-voltage side of the transformers to avoid the very large currents which might otherwise flow in the event of a generator fault. To hold the machines in parallel prior to the application of the short-circuit two single phase 500-kVA transformers have been installed as an auxiliary synchronising tie.

The test bays can also be supplied with power at the alternator voltage or through a step-down transformer. The latter arrangement is used for short-time current-carrying tests during which it may be necessary to maintain a heavy current for periods up to five seconds. It can also be used for testing switchgear at voltages up to 22 kV, although most of this work will continue to be carried out at the original station.

The maximum output of the station is obtained under conditions of full or over-excitation at certain fixed voltages. Up to 22 kV the three-phase output is 2,000 MVA, while between 33 kV and 275 kV it is from 1,500 to 2,500 MVA. At voltages between 66 kV and 380 kV during single phase testing the equivalent three-phase outputs are 3,200 MVA with a recovery voltage of $\frac{1{\cdot}5\,E}{\sqrt{3}}$ or 4,800 MVA with a recovery voltage of $\frac{E}{\sqrt{3}}$.

ALTERNATOR DESIGN

The plant in the new station consists of an alternator manufactured by C. A. Parsons and Company, Limited, Newcastle-on-Tyne, with a frame size equivalent to an output of 60 MVA. The rotor weighs 23 tons and it is driven at a speed of 3,000 r.p.m. by a 1,200-h.p. 5·5-kV induction motor, which is controlled by Reyrolle switchgear with a rating of 150 MVA. The earlier machines, which were also manufactured by Parsons, are of similar size, but their windings are arranged differently and their output is slightly less. All three alternators have two windings per phase, which can be connected in series or parallel or in star or delta to give the basic three-phase voltages of 6·35,

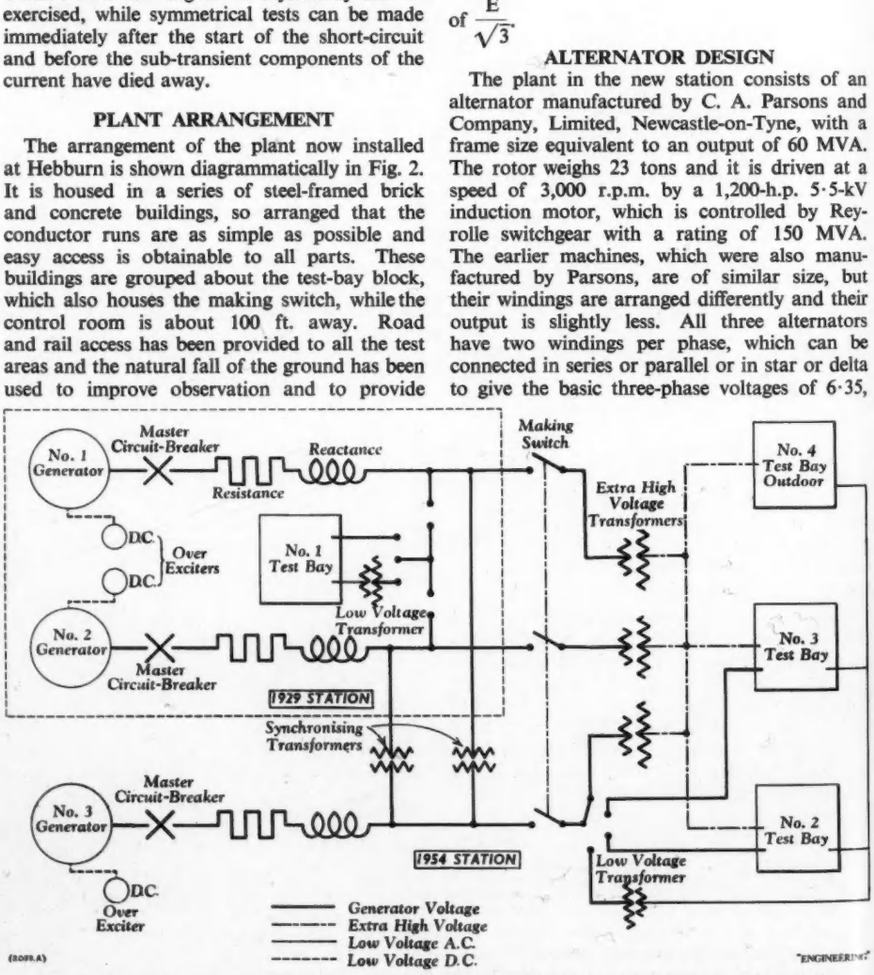


Fig. 2 Diagram of main plant connections at Hebburn high-power switchgear testing station.

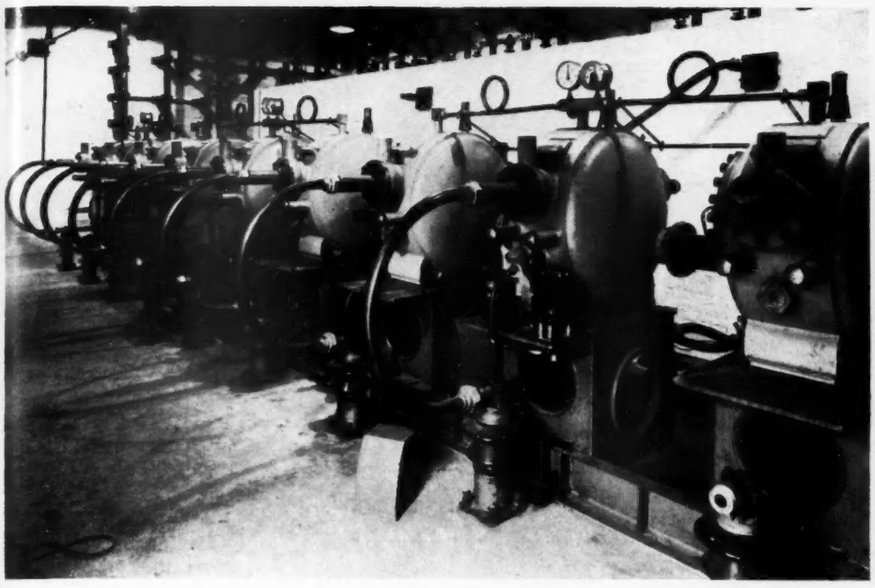


Fig. 3 Three three-phase making switches through which the test short-circuit is normally applied.

11, 12·7 and 22 kV. Intermediate voltages can be obtained by varying the excitation. By the use of the U-connection 19·1 kV can be generated with normal excitation and 22 kV with over-excitation.

The over-exciter set for the latest alternator is driven by a 5·5-kV induction motor at a speed of 750 r.p.m. and has an output of 1,600 amperes at 625 volts. This output is controlled by specially designed switchgear which may have to break 3,000 amperes at 1·5 kV with an appreciable 100-cycle current superimposed when the alternator is short-circuited. The set incorporates a 12½-ton flywheel to improve its characteristics during short-circuit. The over-exciter sets for the earlier machines are similar, but are mounted on a common driving shaft.

As shown in Fig. 2, the alternator outputs are controlled by master circuit-breakers which are a development of Reyrolle's class R switchgear and are fully phase-separated. They can break the full output at any voltage, i.e., 50 kilo-amperes at 22 kV and 80 kilo-amperes at 11 kV. Further control is effected by resistances and reactors, the latter being arranged in two groups. Those controlling the short-circuit current consist of air-cored coils arranged in stacks of three with tapping points and self-locking isolator links to permit rapid circuit changing. The reactors controlling the currents in the load-current range are of the three-phase iron-cored type with a range of 5 to 250 amperes at 11 kV.

MAKING SWITCH

The making switch, through which the short-circuits is normally applied, consists of three three-phase units, one for each generator. It has been designed to precision limits, so that it can be closed at high speed at any point on the voltage wave. To reduce arcing before make the contacts are enclosed in a chamber filled with compressed air at 150 lb. per square inch. Operation is by pneumatically-charged springs, all nine poles being ganged mechanically with clutches between groups of three. These switches, of which an illustration is given in Fig. 3, are capable of making peak currents of over 150 kilo-amperes and are controlled by a thyratron, which is triggered from a 440-volt supply in synchronism with the alternators and tied in with the main test sequence through a master controller.

After passing through the making switch power is supplied to 12 single-phase 11/38-kV transformers and three single-phase 11/152-kV transformers. All these units, manufactured by C. A. Parsons and Company, Limited, are of the shell type, those for the lower output voltage being built on a 12·5-MVA frame size and those for the higher voltage on a 50-MVA frame size. The reactance of the former is 3·3 per cent. and of the latter 3 per cent. The connections on the primary sides are opened, and circuit changes are made, through self-locking isolator links of similar design to those on the reactors. The 152-kV transformers are provided with 11 kV and 22 kV primary windings and four 38-kV secondary windings. The latter can be connected so as to give 38 kV, 76 kV, 114 kV and 152 kV by oil-immersed selector switches and rotary isolators. This method of connection keeps the transformer output almost constant irrespective of the voltage.

The main connections from the alternators to the making switch and from the making switch to the extra-high-voltage transformers consist of two 0·5 sq. in. three-core cables per unit connected in parallel. These cables, which were manufactured by British Insulated Callender's Cables, Limited, Norfolk-street, London, W.C.2, are run in a subway the length of the test block. This subway also contains the control and measurement cables and the oil, water and compressed air services.

TEST BAYS

The output from the extra high voltage transformers is transmitted to two indoor and one outdoor test bays. The indoor bays are large enough to take a 132-kV three-phase circuit breaker and access to them is obtained through reinforced steel swing doors at the rear and motor-operated roller shutter doors at the front, so that they can be completely shut off. The outdoor bay can take a 380-kV three-phase circuit-breaker. All the bays are equipped with low-voltage auxiliaries, measuring cables, an overhead crane, compressed air and oil supplies and fire-fighting facilities. At the side of each test bay is a connection room containing the short-circuit point and the current measuring apparatus. One of these rooms also houses the two synchronising transformers.

The auxiliary equipment includes direct-current generators and batteries for tripping and closing, as well as compressors for operating the pneumatic gear and condensers for controlling the rate of rise of the recovery voltage. The compressors, which were supplied by the Hamworthy Engineering Company, Limited, are oil-cooled

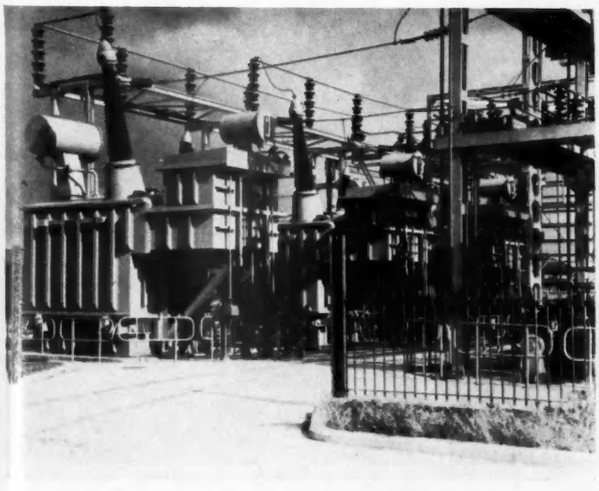


Fig. 4 Extra-high-voltage transformers from each of which a test voltage up to 152 kV can be obtained.

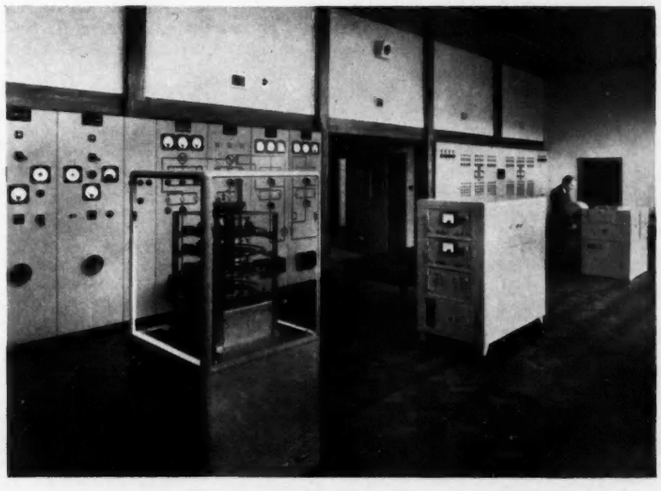


Fig. 5 Control room from which the tests are initiated, showing the test-sequence controller on the left.

and operate at pressures up to 1,000 lb. per square inch. The air is then cooled to remove surplus moisture and expanded to about 600 lb. per square inch, at which pressure it is available as dry air.

OPERATIONAL DETAILS

The tests are controlled from a central building, which also accommodates recording equipment, observation rooms and offices. The main control boards in the control room are arranged along the back wall with electromagnetic and cathode-ray oscillographs and the test-sequence timer in front. The cathode-ray oscillograph, which was designed by Reyrolle's, consists of four 10-kV sealed tubes the records being obtained photographically on a rotating drum. The test-sequence controller has been designed to control the three generators and their exciters, as well as to co-ordinate the test sequence. It consists of four radial arms which are impelled by a spring and rotate in a horizontal plane. During rotation, these arms operate up to 36 lightly-set contacts on a graduated circular scale over a wide range of speeds.

The low-speed records from the Cambridge electromagnetic oscillograph and the high-speed records from the cathode-ray oscillograph, as well as the normal speed cinematograph records taken during the tests and the high-speed cinematograph records of individual components, are dealt with in photographic studios and dark rooms which are so equipped that the various processes can be rapidly handled.

Switchgear is prepared for test in an erection bay a short distance from the test bays. It contains a workshop and cranes as well as means for making preliminary tests and has central heating and an oil-handling plant. The smaller units are usually erected on flat-topped trucks on which they are wheeled into the test bay, but the larger equipment has to be finally assembled in the test bay itself.

TEST PROCEDURE

As regards the conduct of the tests, the driving motors of the main sets are brought up to speed by inserting small resistances in their slip-ring circuits before connecting them to the supply. These resistances are short-circuited when the sets are nearly up to speed. The motors are disconnected before the short-circuits are applied to avoid imposing a sudden load on the supply system. The three sets are initially synchronised with low excitation, sufficient power being generated in this way to hold them in step at no load. The excitation is then raised under manual control, care being taken to ensure that the voltage of each machine is the same. When tests at the highest output are carried out, over-excitation is initiated by a series of definite time-lag relays, which operate in conjunction with the test sequence controller. This over-excitation takes place in two stages by first boosting the exciter field and then the main field.

The short-circuit is next applied at an instant calculated from the known excitation characteristics of the machine. Prior to the tests the circuits are checked on a supervisory panel, which ensures that individual items of plant are not overloaded and that the circuit will produce the required current. The plant in use and the position of the earthing switches are shown on a panel at a point in the control room from which a commanding view of the test bay is obtainable. Finally, a report of performance, upon which the certificate of the Association of Short-Circuit Testing Authorities is issued, is prepared.

The consulting engineers for the equipment of the station were Messrs. Merz and McLellan, 32 Victoria-street, London, S.W.1.

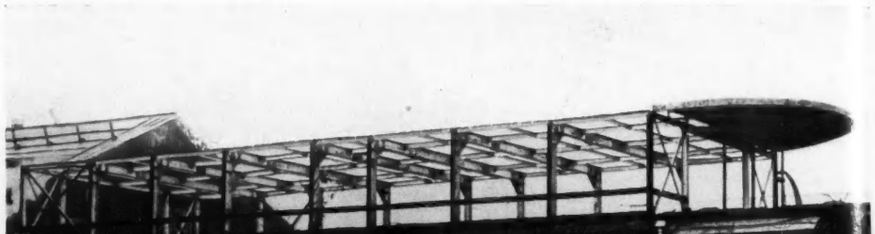


Fig. 1 The addition of an upper storey to this office block was possible because of the relatively small dead loads imposed by the light-alloy framing which is shown in position after erection.

FIRST ALL-WELDED ALUMINIUM PORTAL FRAMES

The use that can be made of light alloys for constructing additional storeys on buildings not originally designed for such extensions is illustrated by some work recently completed by Head Wrightson Aluminium, Limited, Thornaby-on-Tees. In order to increase the accommodation of some offices at Chapel-en-le-Frith belonging to Ferodo Limited, it was decided to build a second storey on top of the existing building. Since this building had not been designed for extensions of this nature, it was essential that the dead loads from the new structure should be kept as low as possible. It was for this reason that aluminium was selected for the framing, and the portal frames that have been made are believed to be the first all-welded in light alloys.

The general outline of the existing building and the framing for the additional storey are shown in Fig. 1. The original building was 75 ft. long by 26 ft. wide and 9 ft. high to the eaves, with a flat roof and a cantilevered canopy.

To eliminate any bending moment on the walls of the existing building due to the fixing of the new column bases, it was decided to adopt a two-pinned portal-frame for the main supports of the new storey. Headroom inside the building was restricted and, as it was essential that the depth of the rafter should be kept to a minimum, the use of welded portal frames as an alternative to riveted latticed construction was preferred.

Having decided on the type of portal frame to be used, the two aluminium alloys selected as being most suitable for this work were HE.10.WP and NP5/6. The principles of design involved were the same as those normally adopted in steel construction and two of the details are illustrated in Figs. 2 and 3. Fig. 2 shows the top knee joint of the frame, and the expedient adopted to simulate pin-joints – curved base plates welded to the legs to form rockers – is shown in Fig. 3.

The semi-circular canopy structure comprises five aluminium-alloy plate girders, extending radially from the main structure and supported at the centre by mild-steel tubular posts. Aluminium-alloy sheets form the roof of the canopy and a false ceiling of asbestos sheets is suspended from the plate girders.

To obtain a uniform slope of the canopy roof sheets, so that rainwater drains on to the main building, it was necessary to tilt the top flanges of the plate girders relative to the webs. This was easily accomplished by using welded construction.

In spite of adverse weather conditions a gang consisting of a foreman and three men were able to erect the structure in 95½ working hours, that is, a total of 382 man-hours. This speed in erection illustrates one of the many advantages to be gained by making use of the lightness of aluminium alloys, the heaviest piece weighing only 2 cwts.

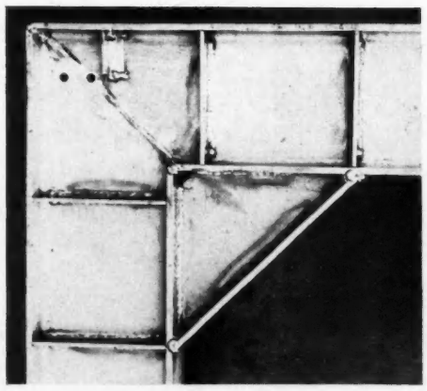


Fig. 2 Orthodox knee joint of the portal frames, which are believed to be the first of entirely welded construction in light alloys.

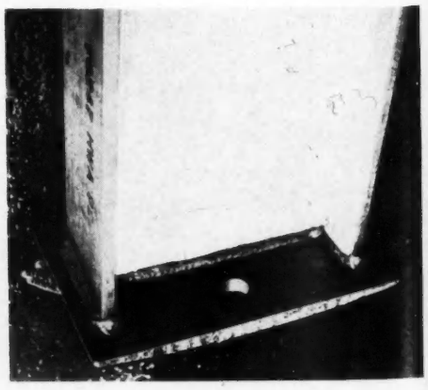


Fig. 3 As the design required the frames to be pinned-jointed, the baseplates, curved to form rockers, were welded to the legs of the frames.

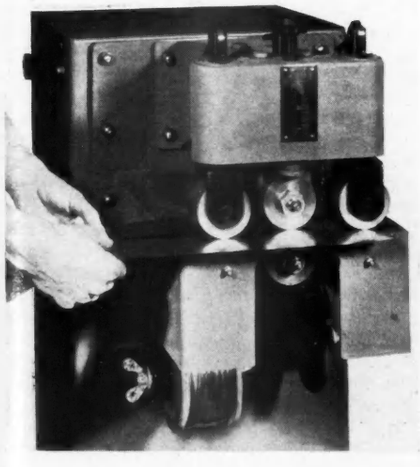
SEAM WELDING WITH WIRE ELECTRODE

Thin metal sheets can be seam welded at a speed of two feet a minute with a new 4-kVA electronically-controlled seam welder developed by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. The machine will seam weld two steel sheets each about 0·010 in. thick, Inconel or nickel sheets about 0·006 in. thick, and brass or copper sheets about 0·003 in. thick. The welds are of 1 cycle ($\frac{1}{50}$th sec.) duration, accurately timed by an electronic circuit using thyratrons and triggered by a multivibrator circuit, in which two gas-filled triodes are coupled to fire in synchronism with the supply-mains frequency. The welds can be spaced 2, 3 or 4 cycles apart to give 42, 31 or 25 welds per inch respectively.

A feature of the machine is the use of a continuous wire electrode. Ordinary 18-S.W.G. soft copper wire is passed continuously through a groove on the periphery of the bottom electrode disc so that it forms the electrode surface. A permanent electrode wheel needs re-dressing and so decreases in diameter thereby presenting difficulties in matching its speed of rotation with that of the feed rollers. The wire is used directly from the reel on which it is supplied. It passes over guide pulleys and round the bottom electrode disc to a driven reel where it is taken up. The wire suffers only a slight burring during the welding operation and can be used afterwards for other purposes.

Both top and bottom electrode discs are of chromium-copper. The bottom disc is driven from a fractional-horse-power geared motor which also supplies the drive to the winding reel and to the lower of each of the two pairs of guide rollers. These rollers, arranged before and after the electrodes, keep the work flat and the seam straight so that long straight seams can be made. The pairs of rollers are lightly spring-loaded to grip the work and the rear or feed rollers have a slightly greater peripheral speed than the front rollers so that the work is kept taut between them. The upper rollers can be lifted clear of the work to allow curved seams to be made. The rollers and electrode discs are clearly shown in the illustration of the work-head of the machine.

The seam welder is operated by means of a single rotary switch with three positions marked "off," "run," and "weld." This ensures that switching is carried out in the correct sequence, the motor being started before welding is begun and switched off only after the welding has been stopped. Welding current can be adjusted by coarse and fine controls. Electrode pressure is variable from 20 to 100 lb. per square inch. Graduated scales are provided to allow current and pressure settings to be recorded. The machine has a welded-steel cabinet with a gun-metal casting to carry the mechanical unit. Sheets up to 14 in. wide can be accommodated. A separate casting carries the upper rollers and electrode system and this can be water cooled to remove heat from the upper electrode. The electronic timer is mounted on a separate chassis within the cabinet and is easily withdrawable. The seam welder is arranged to operate from a 400-440-volts, 50-cycles single-phase supply.



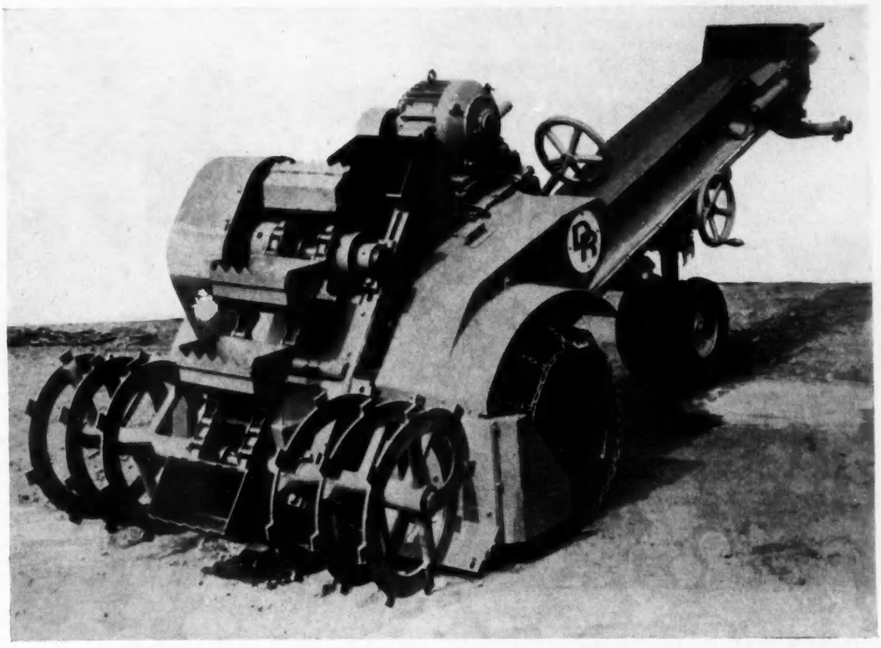
Seam welding thin sheets; the rollers draw the sheets through and keep them flat while the wire passing over the lower disc gives a continuously-renewed electrode surface.

* * *

PRODUCTION OF RUBBER-LIKE RESINS

I.C.I. Plastic Plans

Plans for the large-scale production in this country of a range of rubber-like polymers based on butadiene have been drawn up by Imperial Chemical Industries Limited. Pilot-plant quantities should be available later this year but it is not expected that the full-scale plant at Wilton, North Yorkshire, which will have a planned capacity of about 10,000 tons a year, will commence operations before 1956. Using butadiene produced in the company's oil-cracking plant at Wilton, it is intended to manufacture co-polymers utilising a variety of second components, including acrylonitrile and styrene. These co-polymers will cover a range from oil-resisting substances of the Perbunan type to hard, reinforcing resins. Some of the materials it is proposed to manufacture will be similar to substances already being made in the United States, but others will be novel, both in composition and in properties. The firm's Plastics Division, which has headquarters at Welwyn Garden City, will be responsible for the production, development and sales of the new materials.



The "worms" on each side of the Rotor-loader draw the material toward the buckets, which load it on to the conveyor. A second conveyor can be suspended from the projecting arm.

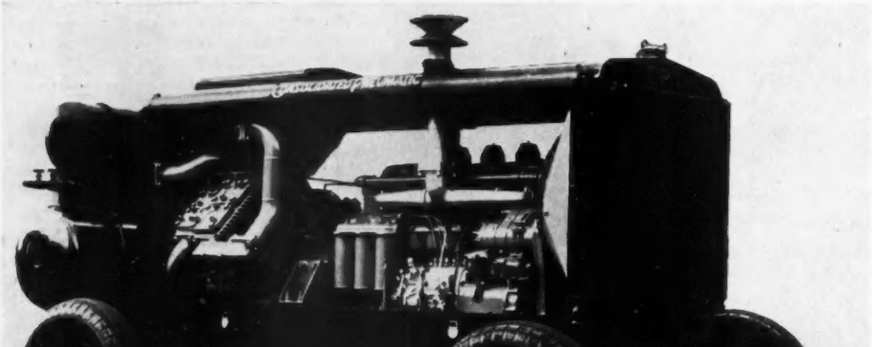
SELF-PROPELLED LOADER

Machine for Handling Loose Material

Designed to handle loose material, such as aggregates and sand, the "Rotor-loader" is made by Moderner Bau-Bedarf, G.m.b.H., of Stuttgart, and distributed in this country by David Roberts and Company (Engineers), Limited, 276 Monument-road, Birmingham, 16. The illustration gives a general view of the machine.

Power for the various movements is supplied either by a 5-h.p. electric motor (as in the illustration) or by a Diesel engine of the same rating; one man can control all operations. The machine is driven under its own power to the heap of material, being steered by the double wheels mounted under the elevator. There is automatic locking of the steering gear when the control is released. The material is then lifted by the buckets on to the elevator and delivered where required. The machine can be arranged to deliver material to a series of "Feather-weight" conveyors, made by the same firm, when hoppers are to be loaded. Each conveyor is separately driven and the whole system can follow the movement of the Rotor-loader as the aggregate heap diminishes. On each side of the elevator buckets is a worm which draws the material inwards to the buckets; the height of the buckets and worms above the ground can be adjusted by the handwheel near the motor. The elevator can be operated independently of the buckets so that the material can be completely discharged from the machine. The steering carriage is telescopic so that the height of discharge may be varied.

The Rotor-loader can handle most loose materials, such as aggregates, sand, gravel, coal, or grain. It has a capacity of between 30 and 50 cub. yards per hour and works most efficiently with sizes of 3 in. or less; it can, however, handle material as large as 6 in. There are two speeds, for manœuvring and loading, and also a reverse. Besides being able to travel under its own power, it can be towed by any vehicle when being moved from site to site.



Consolidated Pneumatic portable compressor fitted with Rolls-Royce oil engine.

PORTABLE COMPRESSOR WITH ROLLS-ROYCE ENGINE

The first transportable air compressor to be driven by a Rolls-Royce oil engine has been added recently to the range of compressors manufactured by the Consolidated Pneumatic Tool Company, Limited, 232 Dawes-road, London, S.W.6. Shown in the accompanying illustration, it comprises a standard PO-40-315 plant mounted on a four-wheeled pneumatically tyred undercarriage fitted with a hand parking brake, and is particularly suited for civil engineering applications. The compressor, a two-stage four-cylinder machine, has a capacity of 315 cub. ft. per minute at 1,250 r.p.m. against a maximum working pressure of 125 lb. per square inch. The bore of the low-pressure cylinder is 8⅜ in., and of the high-pressure cylinder 4¼ in., the stroke of all cylinders being 5 in. The air receiver, mounted at the rear of the chassis, has a capacity of 10½ cub. ft.

All the switches and gauges for controlling the engine and compressor are mounted on a single control panel. The power unit, a Rolls-Royce six-cylinder Diesel engine Type C6NFL, develops 93 brake horse-power at 1,250 r.p.m. (12-hour rating). With a bore of 5½ in. and a stroke of 6 in., the capacity is 742·64 cub. in. It is fitted with a C.A.V. fuel pump and multi-hole atomisers, and is provided with dry-sump lubrication. The electrical system comprises a 24-volt 480-watt dynamo and 165 ampere-hour batteries.

* * *

RUBBER COUPLING FOR PIPES

Simple Device to Accelerate the Laying of Pipe-lines

A new type of pipe-coupling, made of rubber, is now being manufactured and used in the Union of South Africa. The inventor is Mr. J. Kunnen, Director of the Kelt Engineering Company, Proprietary, Limited, Kroonstad, and the couplings are being made by the British and Union Rubber Manufacturing Company, Benoi, Transvaal.

The coupling is notable for its ease of fitting and its simplicity since, essentially, it consists merely of a rubber cylinder which fits inside the ends of the two pipes to be joined. It is slightly smaller in external diameter than the bore of the pipes to be connected but the ends are given a small amount of flare and the cross-section also diminishes longitudinally from the centre towards the ends. Around the external circumference of the cylinder is a rib which, when the joint is made, is gripped by the ends of the pipes and serves, therefore, to locate it so that half the cylinder is in one pipe-end and half in the other.

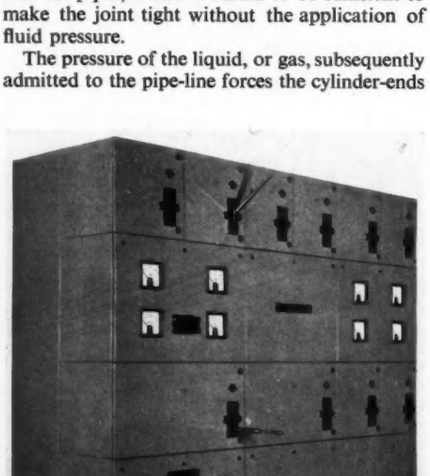
To effect a joint between two pipes, the rubber cylinder, or coupling, is pushed into the barrels of the pipes by hand, the flared ends being squeezed in and as soon as these are released an initial pressure is set up, between them and the pipes, which is stated to be sufficient to make the joint tight without the application of fluid pressure.

The pressure of the liquid, or gas, subsequently admitted to the pipe-line forces the cylinder-ends more firmly against the internal walls of the pipes and a completely self-sealing joint results.

This form of joint can be used to connect piping made from different materials, the only requirements being that the diameter suits the internal bores and that the bores are sufficiently smooth for the first few inches of their length.

The coupling is stated to have been successfully used for joining drawn and welded-steel pipes, spun-concrete pipes and earthenware pipes, which were not specially prepared beforehand.

Under test, the coupling is reported to have withstood successfully a pressure of 475 lb. per square inch. For this test, 4-in. steel piping was used with a deviation of 10 deg. at each joint; this ability to deviate allows for minor settlements and practically eliminates the possibility of pipe-breakage.



"Superform" fuse-switchboard; the operating handles are retractable and the covers can be locked to prevent operation.

* * *

TOTALLY ENCLOSED SWITCHBOARDS

The "Superform" switch and distribution gear made by the English Electric Company, Limited, Kingsway, London, W.C.2, is designed to give a dust-proof panel with a smooth exterior. The illustration shows a fuse-switchboard in this style.

The boards have chassis-mounted front-operated fuse-switches each with quick make and break action. The operating handle, when not in use, is retracted into the switch housing, thus allowing the spring-loaded cover to return to its normal flush-fitting position and prevent the entry of dust. The cover can be locked when the switch is in the "off" position. The operating handles of two of the fuse-switches are shown extended. The panel door is hinged at the left, and secured at the right by two thumbscrews; an interlock is provided so that the door cannot be opened while the switch is in the "on" position. Similarly, the switch cannot be closed with the door open, but provision is made to permit switch operation for inspection and maintenance purposes. "On" and "off" indicators can be seen through a small glass window in the door and are operated from the moving contact-blade assembly.

Flush-type metering can be accommodated to suit individual requirements, and the meter panels are hinged to provide ready access to the instrument connections and small wiring. All terminals are completely insulated and small wiring is enclosed in metallic flexible tubing between the 'bus-bar chamber and meter panel. Both incoming and outgoing cables are located in the compartment at the rear of the switches, the panels at the back of the board being removable to provide access for cabling-up. When they are removed, no live metal is exposed as each back connection from the fuse-switches is completely insulated. Thus spare circuits can be connected up safely with the 'bus-bars "alive" and other circuits on load. At the point of connection of potential circuits to either the 'bus-bars or the outgoing fuse-switch terminals, an H.R.C. fuse is inserted, this being additional to the potential fuses on the instrument panel which are of smaller current rating. Thus an instrument fault is cleared by the potential fuses on the panel as these will discriminate against the larger fuse at the point of supply. The larger rated fuses protect the small wiring. Distribution boards and isolators are also made in the "Superform" design for either surface or flush mounting. Fuse-switches have a range of capacities from 60 to 750 amperes, and the boards are available for either 250 or 500 volts. This fuse-switchboard won the Silver Plaque at the recent Electrical Engineers Exhibition.

Labour Notes

RAILWAY ENGINEERING EMPLOYEES' WAGES

A higher wage increase for engineers employed in railway workshops than that suggested earlier this month, was offered by representatives of the British Transport Commission at a meeting with trade-union leaders on March 26.

The amount suggested by the Commission at the earlier meeting was 7*s.* a week for adult men, with proportionate increases for women and juveniles. These sums were less than the increases offered to the general grades of railwaymen at the beginning of this year, when a settlement was reached for advances varying from 7*s.* to 10*s.* a week.

Some railway shopmen are members of the National Union of Railwaymen, but a large proportion belong to engineering unions and are affiliated to the Confederation of Shipbuilding and Engineering Unions. The engineering unions, in particular, argued that the skilled men belonging to them should receive more than the 7*s.* a week suggested, and pointed out that that sum was no more than the amount granted to the lowest-paid and least-skilful grades among the operating staffs of the railway service.

It is understood that the new offer, like the former, was for a flat-rate increase, and not for a percentage advance, but its precise amount was not disclosed, although it was believed to be about 8*s.* a week for adult men. The trade-union leaders undertook to consider the higher offer and promised to inform the Commission of their decision respecting it in the course of a few days.

As was the case with the engineering and shipbuilding employees, the unions representing the railway shopmen originally presented demands for an all-round advance of 3*s.* in the pound. About 116,000 engineering operatives in the employ of British Railways are expected to benefit from the award, when made.

At the meeting with the Commission's representatives on March 26, Mr. J. S. Campbell, the general secretary of the National Union of Railwaymen, is understood to have been authorised by the union's executive council to inform the Commission that if delays in settling the wage claim were to continue, the executive council would have no alternative but to call for a withdrawal of labour by all members of the union.

A wage increase of 7*s.* 4*d.* a week has been granted to adult men employed in the railway workshops of the London Transport Executive.

ENGINEERING WAGE CLAIM

Representatives of the two sides of the engineering industry were due to meet last Wednesday to give further consideration to the claim of the Confederation of Shipbuilding and Engineering Unions for an overall increase of 15 per cent. in the consolidated time rates of male employees. A special delegate conference of officials from the 38 unions affiliated to the Confederation is expected to be called shortly to discuss the outcome of the meeting.

Following the very firm rejection by the Confederation's representatives of an offer by the Engineering and Allied Employers' National Federation of wage increases slightly in excess of the 5 per cent. suggested by the court of inquiry into the engineering wage dispute, delegates from the unions concerned met in London on March 24 to consider the situation. After various alternatives had been considered, it was decided to ask the employers for a "categorical" reply as to whether they would be able to improve upon their offer, and to seek further meetings with both the engineering and shipbuilding employers' organisations.

The meeting between representatives of the Confederation and the Shipbuilding Employers' Federation to discuss the corresponding wage claim in respect of employees in the shipbuilding and ship-repairing industries was due to be held yesterday.

The outcome of the two meetings was not known at the time of going to press, but there has been no sign that the employers' organisations would be in a position to make better offers. On their side, the trade-union leaders will no doubt have explained that considerable pressure is being brought to bear, by bodies affiliated to the Confederation, for protest action to be undertaken to force a better settlement. The protest action in view would take the form of a ban on overtime and the severe restriction of piecework.

ENGINEERING EMPLOYERS' VIEWS

In a letter to the Confederation on March 25, the Engineering and Allied Employers' National Federation expressed its willingness to meet representatives of the trade unions, if there were any new facts to be considered, but reiterated its inability to offer greater increases in wage rates than those already placed before the unions.

The letter, which was in reply to one from the Confederation, following the delegate meeting in London on March 24, recalled that the Confederation's original claim for an increase of 3*s.* in the pound had been rejected. No alternative offer had been possible because the serious decline in orders and the development of competition in foreign markets did not permit advances in wages and prices to be made.

The court of inquiry into the dispute had suggested an increase of a third of the amount demanded by the Confederation and, although the employers had made an offer which more than met that proposal, they still believed that they were not acting in the interest of either the industry, or its employees, in offering any advance in wages.

POST OFFICE WAGE CLAIM TO BE REHEARD

Arrangements have been made for the rehearing of the telephonists' wage claim, which was withdrawn by the Union of Post Office Workers from the Civil Service Arbitration Tribunal last month, after a dispute had arisen regarding procedure. The union complained to the Minister of Labour that their claim had been rejected before the Tribunal had heard the whole of the evidence, and it requested that the claim should be investigated afresh before a different authority.

An announcement issued on March 26 stated that the union had decided to accept an offer from Sir Walter Monckton for the claim to be reheard at an early date by different members of the same Tribunal, including another chairman. The union declared that the Minister had said that the difficulty had arisen owing to a misunderstanding regarding the Tribunal's intentions.

The claim is for a weekly increase of £1 4*s.* 6*d.* for men and £1 2*s.* for women. When it came before the Tribunal last month, the chairman stated that there was no basis upon which to evaluate the wage scales claimed until the Tribunal had heard the answer of the official side and the union's reply. Some 13,600 men and about 31,900 women telephonists are involved in the claim.

PAY INCREASES FOR COLLIERY CLERKS

Increases in wages, offered by the National Coal Board to their clerical employees, after fairly lengthy negotiations between the Board and the men's unions, the Colliery Officials' and Staffs' Association, affiliated to the National Union of Mineworkers, and the Clerical and General Workers' Union, have now been accepted, according to an official announcement on March 27.

Men employed in the grades concerned are stated to have voted strongly in favour of accepting the increases, which will provide advances ranging from 5*s.* a week for juniors to £25 a year for men in the highest clerical grades in the Board's service.

A statement issued by the Colliery Officials' and Staffs' Association declared that the agreements for giving effect to the increases were now being prepared, for signature by the Board and the unions. It was expected that the Board would make the first payment on the higher scale during the Easter-holiday period. The increases will be effective as from March 1, 1954.

CHANGES IN WAGE RATES IN FEBRUARY

A considerable number of persons had their wage rates increased by small amounts during February. According to a report by the Ministry of Labour, about 1,980,000 workpeople benefited from changes in the full-time rates of wages which came into force in the United Kingdom during that month. The total cost of the increases is estimated by the Ministry to amount to approximately £452,000 a week net.

In the main, the increases principally affected workpeople employed in building and civil-engineering contracting, coal mining and the railway services. Among others who benefited were employees engaged in paper making, heating and ventilating engineering, and trawler fishing.

OVERTIME BAN AT LONDON AIRPORT

Certain grades of maintenance engineers employed by British European Airways at London Airport instituted an unofficial ban on overtime early last week, as a protest against what they allege to be undue delay in settling their claim for higher basic rates of pay. A meeting of shop stewards representing the men concerned, held on March 26, decided that the ban should continue.

Several unions are involved in the claim and they are considering the offer of British European Airways, made at a meeting of the sectional panel of the National Joint Council for the Civil Air-Transport Industry on March 22. It is understood that the offer is for advances of 2*d.* an hour for skilled men, 1¾*d.* an hour for semi-skilled employees, and 1½*d.* an hour for unskilled grades.

LONDON DOCKS OVERTIME DISPUTE

Conciliation officers of the Ministry of Labour made an energetic but unsuccessful attempt on March 24 to find a solution to the overtime dispute at London Docks. They discussed with representatives of the port employers' organisation and officials of the unions concerned, the National Amalgamated Stevedores and Dockers, and the Watermen, Lightermen, Tugmen and Bargemen's Union, the men's claim that the working of overtime should be voluntary.

The employers, relying upon the provisions of the dock labour agreement, consider that reasonable overtime should be performed when required, as a condition of employment. At the meeting on March 24, the employers offered to re-open the whole question if the unions would cancel the restrictions, but the trade-union leaders would not agree unless the employers would first declare that overtime should be voluntary.

The ban was introduced by the stevedores' union on January 25.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Types of Meters and Metering, with Special Reference to the Trivector," by E. H. McCarthy. West London Branch. Windsor Castle Hotel, King-street, Hammersmith, W.6. Tues., April 6, 7.30 p.m.
BOLTON
"Lightning Conductors," by A. Harland. Balmoral Hotel, Bradshawgate, Bolton. Mon., April 5, 7.30 p.m.
ILFORD
"Electric Equipment on the Automobile," by R. J. Smith. North-East London Branch. Angel Hotel, Ilford. Mon., April 5, 8 p.m.
PRESTON
"Fusegear," by E. Jacks. Preston Chamber of Commerce, 49A Fishergate, Preston. Wed., April 7, 8 p.m.

British Institution of Radio Engineers

TREFOREST
"Manufacture of Radio Receiving Valves," by G. P. Thwaites. South Wales Section. Glamorgan Technical College, Treforest, Glamorganshire. Wed., April 7, 6.30 p.m.

Cleveland Institution of Engineers

MIDDLESBROUGH
"Acid Burdening Blast-Furnace Performance," by A. Stirling. Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. Mon., April 5, 6.30 p.m.

Incorporated Plant Engineers

LONDON
"Fans and Fan Engineering Equipment," by C. J. Atkins. Royal Society of Arts, John Adam-street, Strand, W.C.2. Tues., April 6, 7 p.m.
DUNDEE
"Industrial Uses of Magnetic Power," by T. G. Hawker. Mathers Hotel, Dundee. Mon., April 5, 7.30 p.m.
EDINBURGH
Film Evening. 25 Charlotte-square, Edinburgh. Tues., April 6, 7 p.m.
SOUTHAMPTON
Discussion on "Feed-Water Treatment." Polygon Hotel, Southampton. Wed., April 7, 7.30 p.m.

Institute of British Foundrymen

BRADFORD
Prize-winning paper in the S. W. Wise Memorial Competition. West Riding of Yorkshire Branch. Technical College, Bradford. Wed., April 7, 7.30 p.m.
LUTON
"Recent Developments in British Foundries, with Special Emphasis on Shell Moulding," by A. S. Beech. Bedfordshire and Hertfordshire Section. Conservative Club, Luton. Thurs., April 8, 7.30 p.m.
MANCHESTER
"Mechanical Aids in the Foundry," by J. Blakiston. Lancashire Branch. Engineers' Club, Manchester. Wed., April 7, 7 p.m.
NEWCASTLE-UPON-TYNE
Annual General Meeting and Film Evening. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Sat., April 10, 6 p.m.
SHEFFIELD
"Use of Feeding Materials," by D. H. Snelson. Sheffield College of Commerce and Technology, Pond-street, Sheffield, 1. Mon., April 5, 7.30 p.m.

Institute of Fuel

LONDON
Annual General Meeting (for corporate members of the Institute only), 4.30 p.m. Presidential Address by Dr. W. Idris Jones, 5.30 p.m. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., April 8.
GLASGOW
Annual General Meeting. "High-Temperature Heating Fluids," by C. M. Auty. Scottish Section. Royal Technical College, Glasgow. Fri., April 9, 7 p.m.

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LARGE DAMS

Paris Congress Next Year

The International Commission on Large Dams, which is affiliated to the World Power Conference, will hold its fifth congress in Paris next year, commencing on Tuesday, May 31. About a week will be devoted to technical sessions, after which a study tour of dams in France and North Africa will be undertaken.

Four main subjects are due to be discussed at the technical sessions. Three of these will comprise the design and construction of dams on permeable soils and methods of foundation treatment, the economics and safety arrangements of different types of concrete dams, and the settlement of dams owing to the compressibility of the building materials or of the foundation soil. Earthquake problems will be discussed under the third heading.

The fourth subject will be the relation of the cement content of concrete to the practical performance of gravity dams (interior and exterior), arch dams, and buttress dams, and its influence on permeability and frost resistance.

Offers of papers coming within the scope of one of these four subjects are invited from engineers residing in Great Britain by the British national committee, 201-2 Grand Buildings, Trafalgar-square, London, W.C.2. The name and address of the author, the title of the paper, and an estimate of its length should be submitted to the committee not later than May 31, 1954.

Institute of Marine Engineers

BIRMINGHAM
"Heat Exchangers," by H. E. Upton. West Midlands Section. Imperial Hotel, Birmingham. Thurs., April 8, 7 p.m.
LIVERPOOL
Symposium on "Some Interesting Ship and Machinery Defects: Their Investigation and Cure." Merseyside and North-Western Section. 24 Dale-street, Liverpool. Mon., April 5, 6.30 p.m.

Institute of Road Transport Engineers

GLASGOW
"Metal Spraying and Building-up Processes," by J. Stuart Scott. Scottish Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., April 5, 7.30 p.m.
NOTTINGHAM
"Lighting for Commercial Vehicles and Its Contribution to Road Safety," by G. C. Charlesworth. East Midlands Centre. Mechanics' Institute, Nottingham. Wed., April 7, 7.30 p.m.
PRESTON
"Light-Weight Bodies," by Colin C. Bailey. North-West Centre. Victoria Station Hotel, Preston. Tues., April 6, 7.30 p.m.

Institute of Welding

LONDON
Annual General Meeting. "Some Aspects of Non-Destructive Testing," by Dr. J. S. Blair. South London Branch. 2 Savoy-hill, W.C.2. Thurs., April 8, 6.30 p.m.
SLOUGH
Annual General Meeting. Community Centre, Farnham-road, Slough, Buckinghamshire. Thurs., April 8, 7.30 p.m.

Institution of Civil Engineers

LONDON
"Land Drainage in England and Wales," by E. A. G. Johnson. Hydraulics Engineering Division. Tues., April 6, 5.30 p.m.
BIRMINGHAM
"Rainfall Run-Off and Storage, Elan and Claerwen Gathering Grounds," by C. A. Risbridger and W. H. Godfrey. Midlands Association. James Watt Memorial Institute, Birmingham. Thurs., April 8, 6 p.m.
HULL
Annual General Meeting. "Economic Factors in the Choice of Designs," by D. E. Glover. Yorkshire Association. Electricity Showrooms, Ferensway, Hull. Wed., April 7, 6.15 p.m.
MANCHESTER
"Six Similar Shaft-Sinking Accidents, 1905 to 1952: Precautions Necessary with Cast-Iron Linings in Compressed Air," by I. C. Easton. North-Western Association. Engineers' Club, Manchester. Thurs., April 8, 6.30 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "Technical Problems Involved in Receiving Alternative Television Programmes." Radio Section. Mon., April 5, 5.30 p.m.
"Determination of the Static and Dynamic Elastic Properties of Resilient Materials," by R. S. Jackson, Dr. A. J. King and C. R. Maguire; "A Method of Using Microwaves for Measuring Small Displacements and a Torque Meter Using This Principle," by N. C. de V. Enslin (to be read by Professor R. Guelke); and "Magnetic Measurement of Mechanical Hardness," by D. Hadfield. Measurements Section. Tues., April 6, 5.30 p.m.
Symposium on "Recent Work on Transistors." "A Versatile Transistor Circuit," by E. H. Cooke-Yarborough; "The Measurement of the Small-Signal Characteristics of Transistors," by E. H. Cooke-Yarborough, C. D. Florida and Dr. J. H. Stephen; "A Bridge for Measuring the Alternating-Current Parameters of Type A Transistors," by Dr. A. R. Boothroyd and L. K. Datta and "The Transistor as a Regenerative Amplifier, with Some Application to Computing Circuits," by G. B. B. Chaplin. Joint Meeting of Measurements and Radio Sections. Wed., April 7, 5.30 p.m.
ARBORFIELD
"Machines, Animals and Information," by B. Z. de Ferranti. London Students' Section. R.E.M.E. Training Centre, Hazebrouck Barracks, Arborfield, Berkshire. Thurs., April 8, 6.30 p.m.
LIVERPOOL
Annual General Meeting. "Technical Arrangements for the Sound and Television Broadcasts of the Coronation Ceremonies on June 2, 1953," by W. S. Procter, M. J. L. Pulling and F. Williams. Mersey and North Wales Centre. Liverpool Royal Institution, Colquitt-street, Liverpool. Mon., April 5, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Performance of Compression-Ignition Engines Under Abnormal Conditions, Including Altitude, Temperature, Humidity, Load, Speed or Speed Variation, and Fuel Supply." Internal-Combustion Engine Group. Wed., April 7, 6.45 p.m.
"Observation and Control of Dust at Pneumatic Chisels," and "Observation and Control of Dust at Portable Abrasive Wheels," by W. B. Lawrie, A. T. Holman and E. B. James. Industrial Administration and Engineering Production Group. Fri., April 9, 5.30 p.m.

Institution of Production Engineers

LONDON
"Potentialities of Titanium," by J. C. Campbell. Royal Empire Society, Craven-street, W.C.2. Thurs., April 8, 7 p.m.
LIVERPOOL
"Defects and Developments in Deep Drawing and Pressing," by Dr. J. D. Jevons. Liverpool Graduate Section. Exchange Hotel, Liverpool. Fri., April 9, 7.30 p.m.
MANCHESTER
"The Electrification of the Manchester-Sheffield-Wath Line," by A. H. Emmerson. Manchester Graduate Section. College of Technology, Sackville-street, Manchester. Thurs., April 8, 7.15 p.m.
NOTTINGHAM
"The Electron Microscope," by W. J. Lloyd. Victoria Station Hotel, Milton-street, Nottingham. Wed., April 7, 7 p.m.
SWANSEA
"Metallurgy and Its Importance to the Production Engineer," by Dr. A. R. E. Singer. West Wales Section. Central Library, Alexandra-road, Swansea. Fri., April 9, 7 p.m.
WOLVERHAMPTON
"The Industrial Applications of Radio-Active Materials," by Sir John Cockcroft. Wolverhampton and Staffordshire Technical College, Wolverhampton. Wed., April 7, 7.15 p.m.

Institution of the Rubber Industry

BURTON-ON-TRENT
Annual General Meeting and Film Evening. Midland Hotel, Station-street, Burton-on-Trent. Tues., April 6, 7.15 p.m.
NEWCASTLE-UPON-TYNE
Annual General Meeting. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., April 5, 7 p.m.

Institution of Structural Engineers

NEWCASTLE-UPON-TYNE
Annual General Meeting. Northern Counties Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., April 7, 6.30 p.m.

Institution of Works Managers

LONDON
"Factory Safety and the Works Manager's Responsibility in that Field," by Sir George P. Barnett. Waldorf Hotel, Aldwych, W.C.2. Thurs., April 8, 7 p.m.

Junior Institution of Engineers

LONDON
"Modern Laundry Machinery," by A. J. Simpson. Townsend House, Greycoat-place, S.W.1. Fri., April 9, 7 p.m.
BIRMINGHAM
"The Development of Steam Power," by W. K. V. Gale. Midland Section. James Watt Memorial Institute, Birmingham. Wed., April 7, 7 p.m.

Liverpool Metallurgical Society

LIVERPOOL
"The Cold Working of Metals," by J. G. Wistreich. Annual General Meeting. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Thurs., April 8, 7 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"The Development of Ore Carriers in Recent Years," by W. A. Stewart. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., April 5, 6.15 p.m.

Royal Meteorological Society

LONDON
"Heat Convection and Buoyancy Effects in Fluids," by Dr. G. K. Batchelor. Symons Memorial Lecture. Wed., April 7, 5 p.m.

Royal Society of Arts

LONDON
"The Meteorological Office and the Commonwealth," by Professor O. G. Sutton. Thurs., April 8, 5.15 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Analysis of Permanent Magnet Alloys," by W. Wright. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., April 6, 7 p.m.

Society of Engineers

LONDON
"Brittle Fracture in Steel Structures, with Special Reference to Liberty Ships," by Dr. A. A. Wells. Geological Society's Apartments, Burlington House, Piccadilly, W.1. Mon., April 5, 5.30 p.m.

Society of Instrument Technology

LONDON
Discussion on "Rationalisation of Units for Electrically-Operated Servos." Manson House, Portland-place, W.1. Thurs., April 8, 7 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
Annual General Meeting. "Bright Steel Bar Production," by R. R. Russell, W. G. Reid and A. Fisher. Fri., April 9, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 54 Station-road, New Barnet, Hertfordshire. (BARnet 9141.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Cleveland Institution of Engineers, 5 Ambleside-road, Normanby, Middlesbrough.
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. (SLOane 9851.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 36 Portman-square, London, W.1. (WELbeck 6813.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Works Managers, 67-68 Chandos-place, London, W.C.2. (TEMple Bar 8324.)
Junior Institution of Engineers, 39 Victoria-street, London, S.W.1. (ABBey 6968.)
Liverpool Metallurgical Society, 55 Tudorville-road, Bebington, Cheshire. (Rock Ferry 4878.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 1. (Newcastle 20289.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Sheffield Metallurgical Association, 15 Crescent-road, Sheffield, 7. (Sheffield 53674.)
Society of Engineers, 17 Victoria-street, London, S.W.1. (ABBey 7244.)
Society of Instrument Technology, 55 Tudor-gardens, London, W.3.
West of Scotland Iron and Steel Institute, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)